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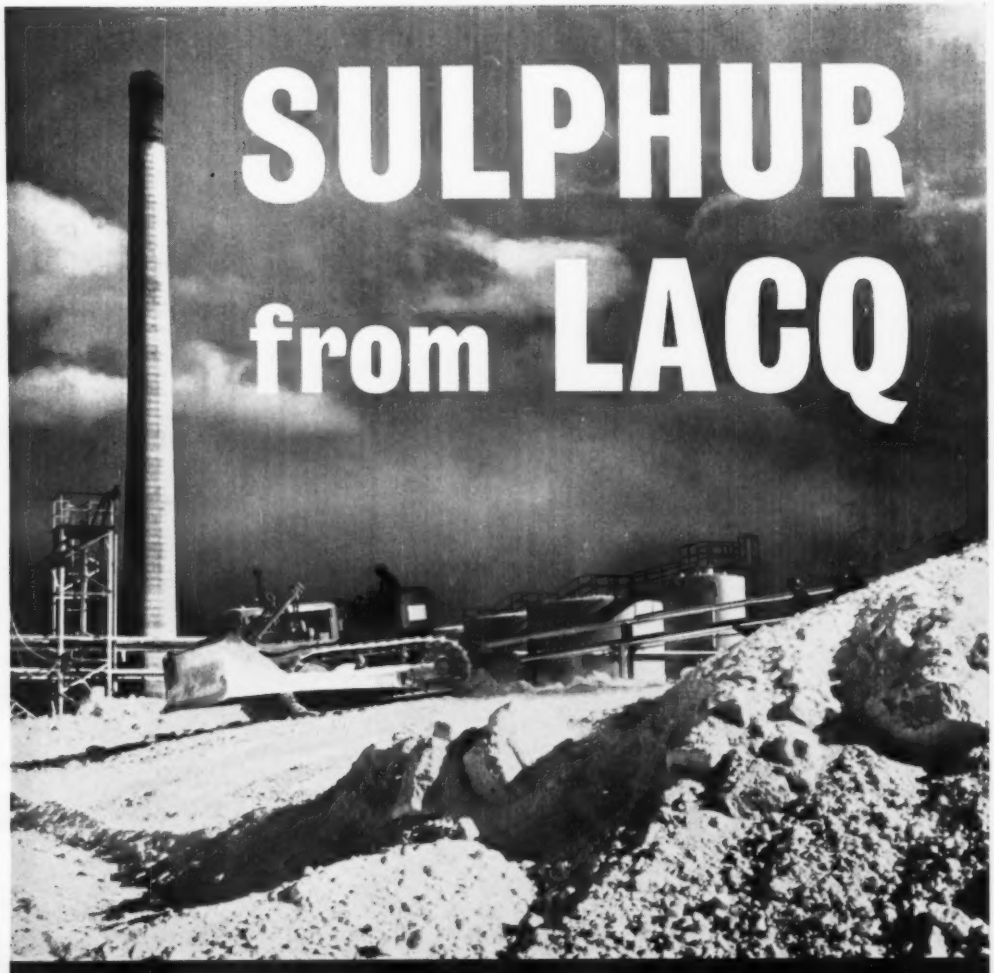

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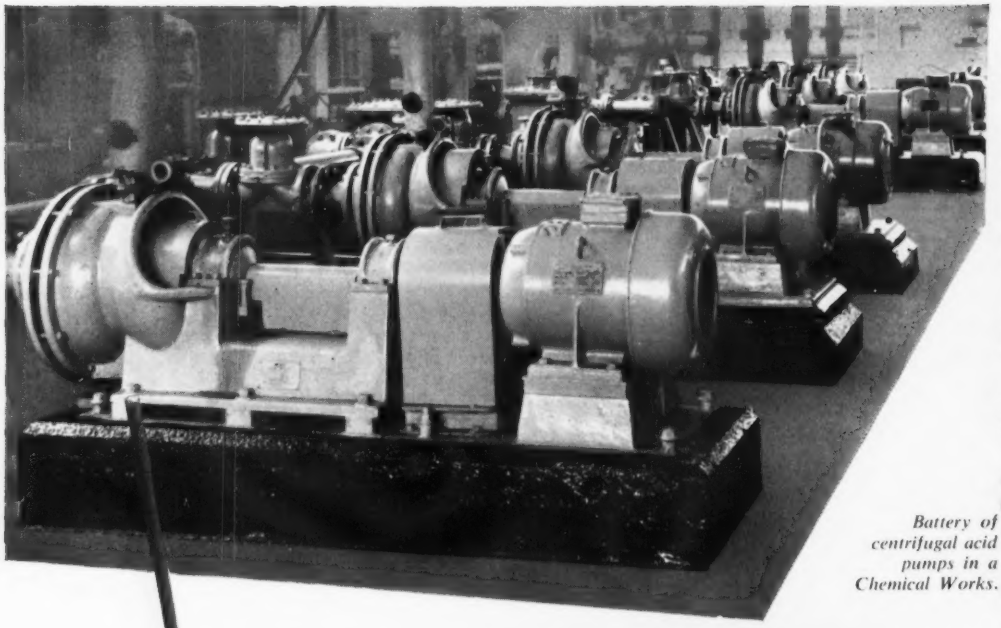

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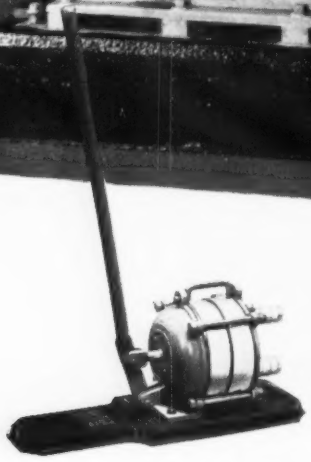

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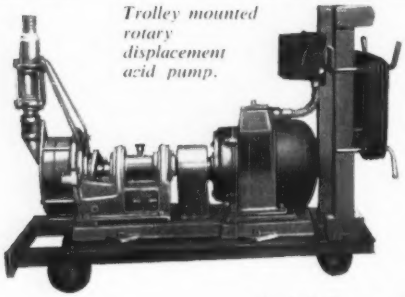

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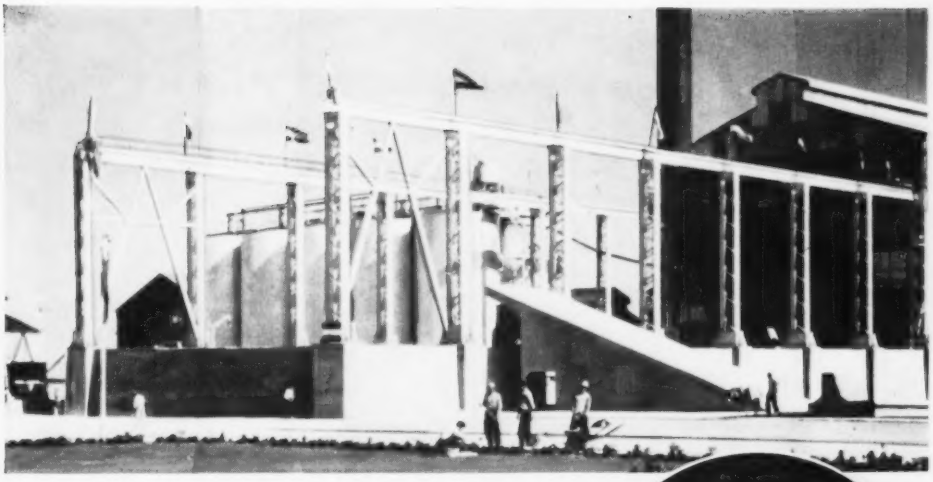

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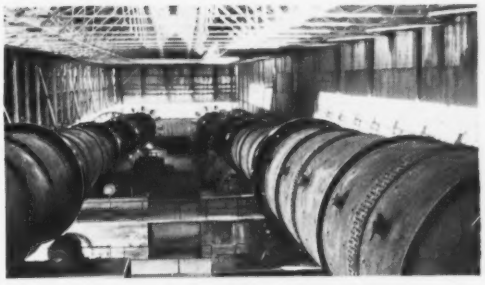

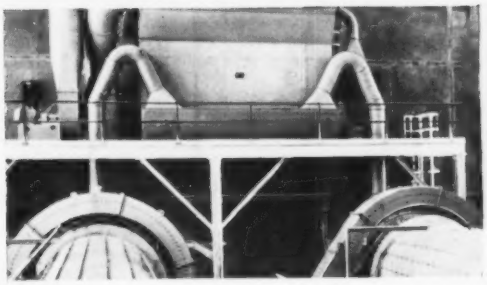

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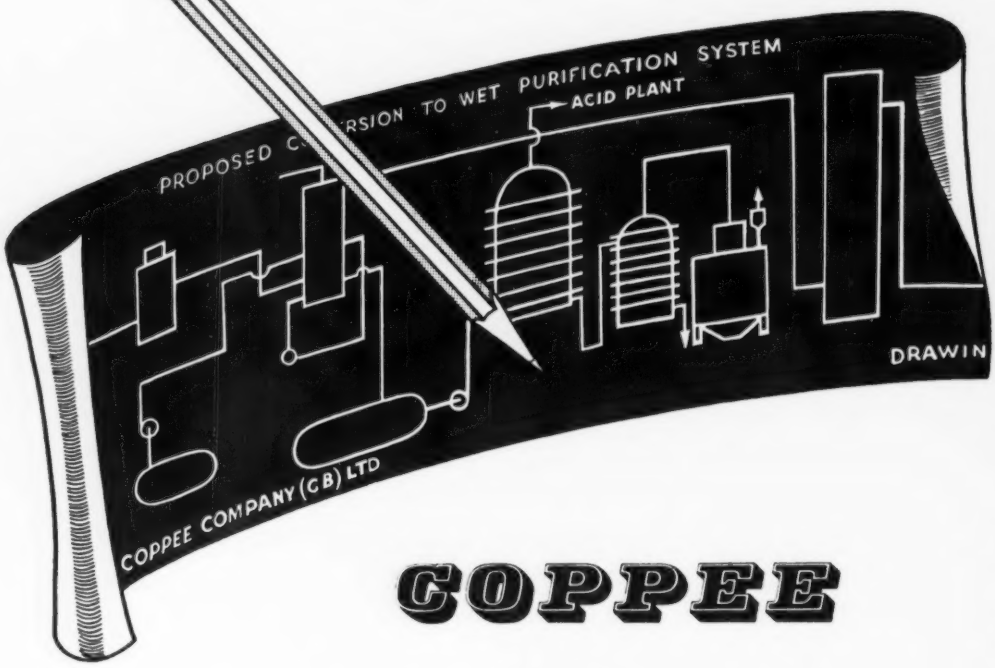

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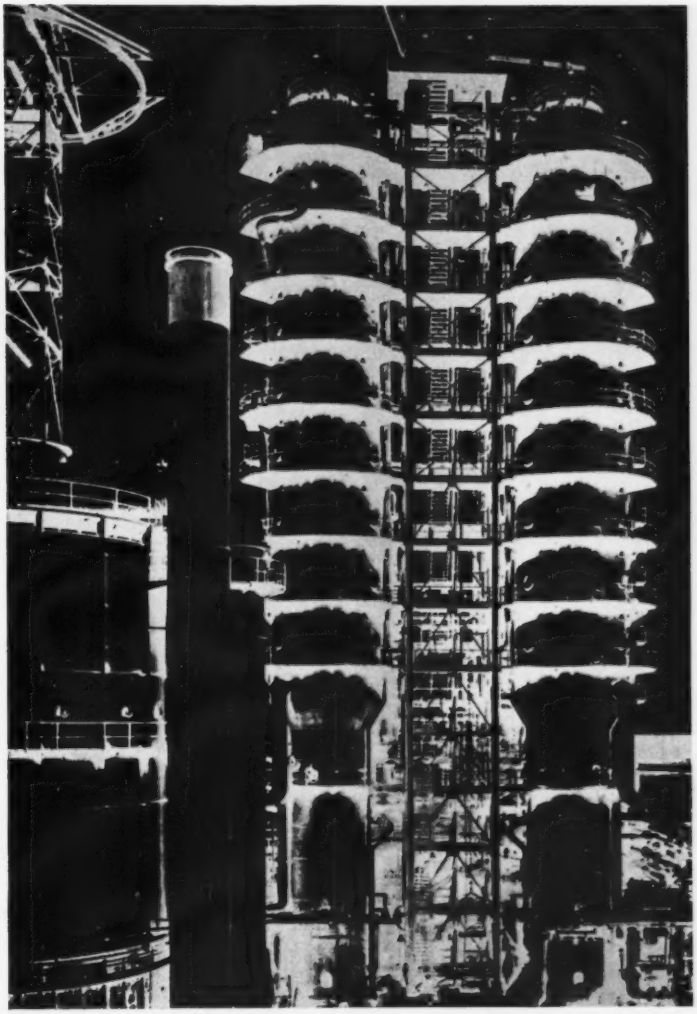

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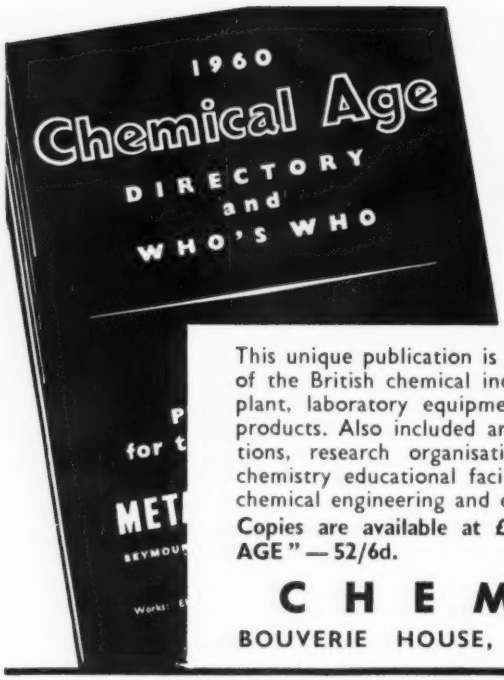

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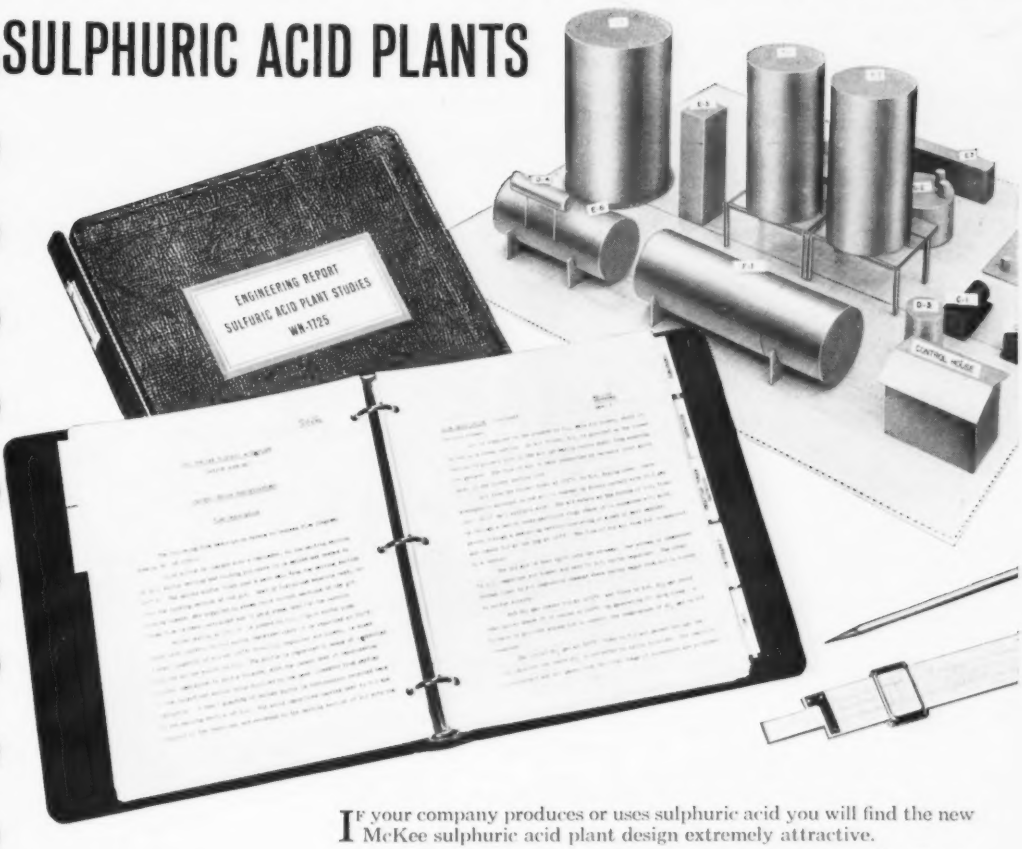

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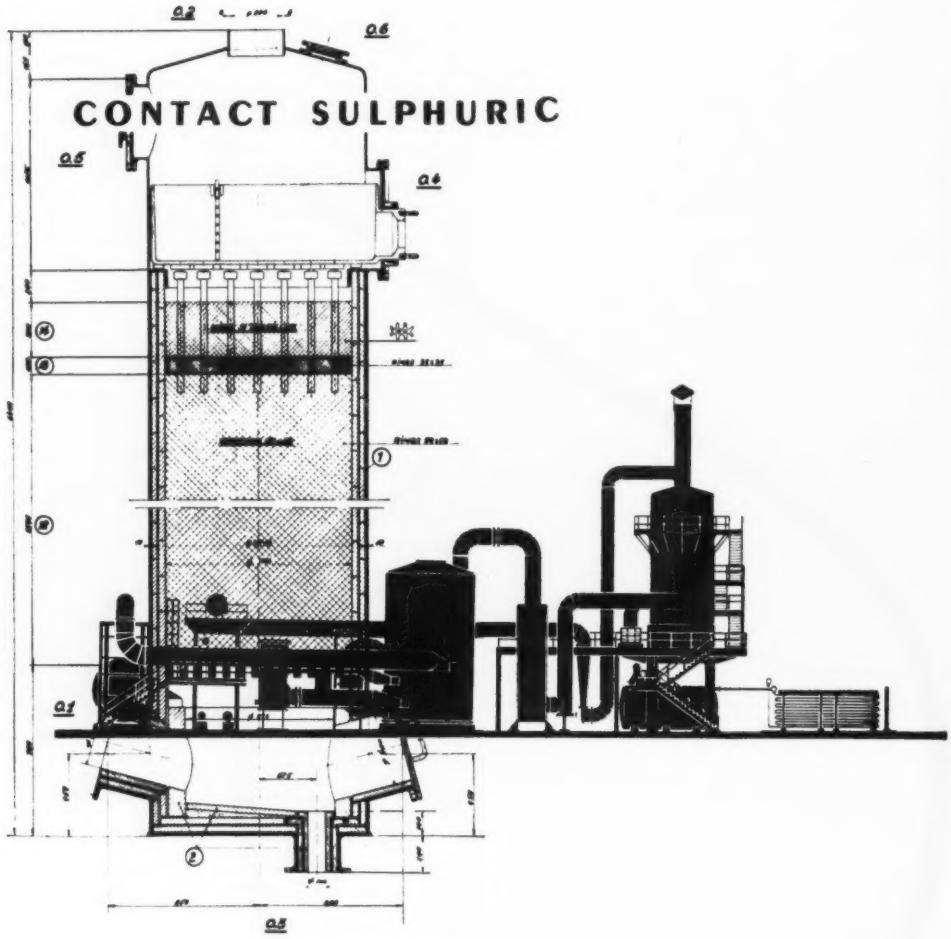

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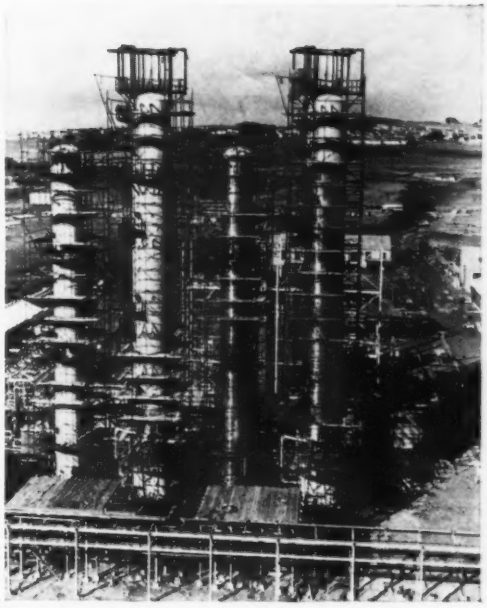
Sulphur Removal Techniques at Some New U.K. Gas-Producing Plants

IN U.K. gas industry to-day, the emphasis now is on new manufacturing processes. More than competitive with conventional carbonising plant are the Segas and Shell processes of gasification now in operation at the South Eastern Gas Board's Isle of Grain Works, while one in operation at the end of this year is the Westfield Works of the Scottish Gas Board which is based on the principle of high-pressure gasification of small opencast-mined coal by the Lurgi process — the first of its kind in Britain although technically proven on the Continent.

With the statutory requirements concerning pollution of atmosphere, especially with regard to hydrogen sulphide, much attention has had to be paid to plant design to produce a sulphur-free gas with a greatly reduced content of carbon monoxide. It is therefore of interest to examine the processes and techniques chosen to comply with these requirements. The processes were discussed in considerable detail at the 97th Annual General Meeting of the Institution of Gas Engineers held in Edinburgh at the beginning of June.

ISLE OF GRAIN WORKS

Established at S.E.G.B.'s Isle of Grain Works is Stage I employing the Segas process, based on the cracking of vaporised fuel oil when passed with steam through a catalyst, which was commissioned late in 1958. Stage II, based on the Shell process of gasification at elevated pressures of continuous non-catalytic partial oxidation of petroleum hydrocarbons when fed with oxygen and steam to a combustor, is in course of construction and will be commissioned later this year. A further stage of development is planned — Stage III — consisting of duplication of the additional gasification and gas treatment plant installed at Stage II*.



View looking west on Benfield vessels, showing the right-hand two vessels almost completely clad with outer protective sheath of aluminium. The left-hand two vessels are lagged but no aluminium has yet been applied

Segas Plant

For Stage I, four units of Segas plant have been installed each having a nominal capacity of 4 million cu. ft./day when using heavy fuel oil (H.F.O.) as feedstock rising to 5 million cu. ft./day on light gas works feedstock (L.G.F.) and to 5½ million cu. ft./day on refinery gas. The gas made in each unit after being scrubbed and detarred passes on through naphthalene washers to six oxide purifiers, each containing 9,500 cu. ft. of oxide. These are of tower pattern, with 11 trays per tower, each carrying 16 tons of purifying material. The towers are served by a Goliath crane and the Newton

*"Gasification at the Isle of Grain" by C. Stott. Paper presented at the 97th Annual General Meeting, Institution of Gas Engineers, Edinburgh, June, 1960.

Chambers' system for the mechanised discharging and refilling of trays. As change of feedstock from L.G.F. to H.F.O. produces a gas high in organic sulphur content, intensive oil washing is essential. A benzole defronting and desulphurisation unit from W. C. Holmes Ltd. has been installed. Provision has thus been made for removal of 90% of the carbon disulphide as well as for efficient recovery of benzole. (See also P.30).

Shell Gasification Treatment Plant

When produced from heavy fuel oil 4% of sulphur, the water gas leaving the Shell gasification plant will carry approximately 550 gr. of hydrogen sulphide and 50 gr. of organic sulphur/100 cu. ft. at S.T.P. It was proposed originally that sulphur compounds would be removed from the hydrogen gas stream using the "Seblu" process whereby the hydrogen sulphide in the gas leaving the Shell plant was to be removed by absorption in an aniline solution of methylene blue. Organic sulphur compounds could be converted to hydrogen sulphide in carbon monoxide converters, and this would be removed by a second stage of methylene blue absorption. The solutions from the two absorbers would be treated in a common plant for recovery of sulphur in crystalline form.

High hopes had been placed on the "Seblu" process by S.E.G.B. for the method simplifies removal of sulphur from gases, and the cost of the plant has been estimated at being considerably less than the alternative methods at present available. At the time the plant was in the design stage development work on the "Seblu" process had not proceeded far enough to justify its application to full-scale operation, and alternative methods had to be sought.

Thus the Alkazid process was adopted for removal of H_2S from the gas before the inlet to the carbon monoxide converters. H_2S and approximately an equal volume of CO_2 removed in regenerating the wash liquor are passed into the Segas gas stream or into the refinery gas stream and absorbed in the existing low-pressure system of tower purifiers. These are therefore being extended to meet the additional duty. Gas leaving the CO converters increases in volume by approximately 33% due to the conversion of the CO to hydrogen and CO_2, and will contain, per 100 cu. ft. at S.T.P., a few grains of hydrogen sulphide as slip from the Alkazid plant and about 30 gr. of hydrogen sulphide from the organic sulphur conversion. This hydrogen sulphide has to be removed prior to passing to the CO_2 removal plant. It is planned to carry out the removal in a stream of five high-pressure tower purifiers.

Sulphur Content of Isle of Grain Feedstocks

Hydrogen sulphide (gr./100 cu. ft.)	220-350	3 to 15	5—50
Carbon disulphide (gr./100 cu. ft.)	16.32		—
Carbon oxysulphide (gr./100 cu. ft.)	2.5	4	—
Ammonia (gr./100 cu. ft.)	<0.1	<0.1	<0.1
Benzole (Gal./10.000 cu. ft.)	—	2.83	2.91
Gum (gr./mill. cu. ft.	<30	<30	<30

*Acetylene 1.0 to 2.5 †Acetylene 0.5 to 1.5

Typical Characteristics of Feedstocks

Light Oils

	Stabilised Light Distillate	Straight-run Benzene
Sp. gravity	0.662	0.72—0.74
Calorific value (B.th.U/lb.)	20.600	20,260—20,370
Sulphur (% by weight)	<0.1	<0.1
Initial boiling-point (°C)	39	78
Final boiling-point (°C)	150	153
50% evaporated (°C)	52	102
Olefin content (% by vol.)	0.5	1.0
Aromatic content (% by weight)	1.5	5—13

Heavy Fuel Oil

	Type I	Type II
Sp. Gravity	0.906	0.946—0.949
Flash point (°F)	256	216—240
Sulphur (% by weight)	2.6	2.3—3.5
Viscosity at 100 °F No. 1 Red. Secs	121	560—960
Carbon Residue (Connadsen) (% by weight)	3.4	4.3—7.4
C/H ration (calc.)	7.2	7.3
Calorific value (B.Th.U./lb)	1,875	1,825

Characteristics Typical of Gas made from Different Feedstocks

Feedstock analysis of gas	Heavy Fuel Oil	Light Distillate	Refinery Gas
Carbon dioxide (%)	10.5	4.1	3.7
Oxygen (%)	0.6	0.7	0.6
Unsaturated hydrocarbons	6.2*	3.0	3.5†
Carbon monoxide	11.8	14.9	14.4
Hydrogen	44.7	52.5	54.6
Ethane	1.9	1.7	1.8
Methane	18.3	17.7	18.7
Nitrogen	6.0	5.4	2.7
Total	**100.0**	**100.0**	**100.0**

Alkazid Plant

The two gas streams from the Shell plant continue for treatment in the Alkazid plant. The gas enters the base of an absorber containing bubble cap trays through which the glycine lye passes. The rich lye is preheated in passing through a heat-exchanger where hot stripped lye is in counter flow. It is depressurised in a stripping tower and H_2S and some CO_2 is removed by heating indirectly with steam. Sour gases leave the stripper, pass through a cooler and are finally dealt with in the low-pressure tower purifier system.

Gas leaving the final cooler of the conversion plant passes to a series of high-pressure purifiers designed for backward rotation. Five towers are provided of 8ft. 6in. diameter, loaded with ten trays. The trays are of 7ft. 6in. diameter with a 2ft. 9in. layer of oxide, and are arranged for downward flow of gas. A gas heater on the inlet gas is provided to maintain a working temperature of 100°F.

As replacement and recharging with fresh oxide at frequent intervals will be required, a quick-release type of cover is being installed, which will avoid the removal and replacement of the large number of bolts associated with the conventional type of flanged joint on a high-pressure vessel. This consists of a locking ring of the bayonet type operating between a flange on the lid and lugs on the tower body. Application of gas-pressure to the underside of a rubber joint ring makes the joint between lid and body gas tight. Provision is made also against removing the cover while the tower is still under pressure by preventing any movement of the locking ring until a vent to atmosphere has been opened.

Two stocking towers designed for normal pressures are provided — one to receive a set of trays from a tower when the oxide is spent, and the other to accommodate a set of trays charged with fresh oxide. Oxide is removed from the trays by tipping. Two compressors supply the air required for regenerating the oxide *in situ*. One will serve as standby to the other and each will deliver 12,000 s. cu. ft./hr. at 300lb./sq. in — sufficient to give 0.2% of excess oxygen in the purified gas.

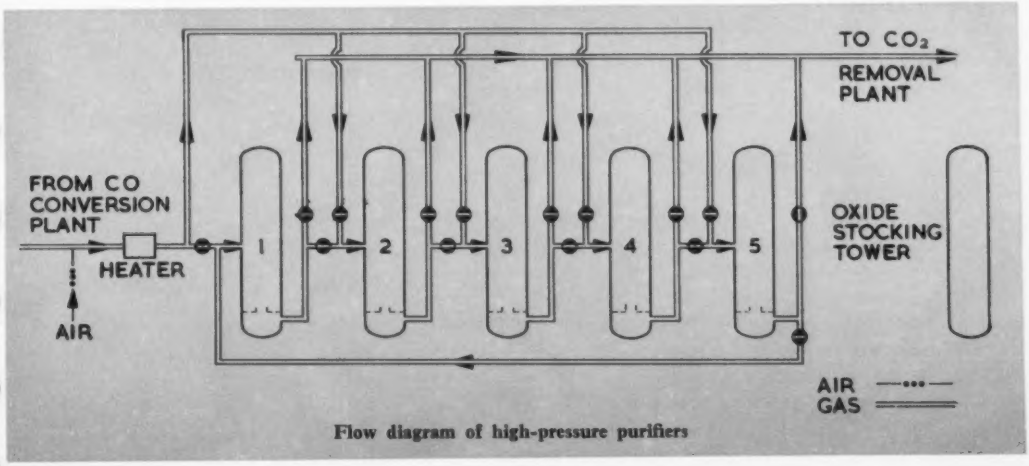
Estimated Sulphur Removal Costs

	Stage II		Stage III	
	2*	3*	4*	5*
H_2S Removal by Alkazid "Sour" gas treatment in low-pressure tower	0.51d.		0.46d.	
	0.37d.	0.88d.	0.37d.	0.83d.
H_2S removal by high-pressure oxide purifiers		0.58d.		0.50d.

* 2, 3, 4 and 5 refer to types of feedstocks.

Capital expenditure on the Alkazid plant for Stage II is estimated at £103,200 and for the high-pressure purifiers at £232,000.

Sulphur recovered by South Eastern Gas Board at this works as spent oxide goes to Greenwich for manufacture of sulphuric acid which is used in concentrated ammonia liquor for production of ammonium sulphate.



Flow diagram of high-pressure purifiers

WESTFIELD WORKS

A number of unusual features are incorporated in the Westfield Works' purification system. Responsible for design, procurement, construction and commissioning of the plant have been Humphreys and Glasgow Ltd., in their capacity as main contractors and consultants.

Describing the plant at Westfield in a paper* recently, T. S. Ricketts pointed out that the Lurgi process results in a high CO_2 content in gas leaving the gasifier (approximately 27%) while the H_2S content is of the order of 0.8%. CO_2 and H_2S may be absorbed simultaneously in the same plant, or a certain degree of absorption may be carried out in separate plants. In the former case, when the absorption solution is regenerated, a waste gas is produced that consists of a weak concentration of H_2S and CO_2; in the latter case H_2S produced upon regeneration will be more concentrated, and the task of conversion into saleable sulphur or sulphuric acid may be made easier, according to local circumstances.

At Westfield the hot potassium carbonate process has been adopted whereby simultaneous removal of CO_2 and H_2S takes place in the plant, known as a Benfield plant after its inventors, Benson and Field, of Pittsburg, U.S.A.

Benfield Plant

CO_2 and H_2S is absorbed in 35% solution of potassium carbonate at high pressure and a temperature of approximately 110°C the two gases reacting with the potassium carbonate to form potassium bicarbonate and potassium disulphide respectively. The solution leaves the absorber and, after a reduction of pressure from 325lb. / sq. in to 5lb. / sq. in., passes to a regenerator vessel where conventional steam stripping is carried out at the same temperature. This avoids the need for heating the solution between absorption and regeneration, and hence saves steam and heat-exchange equipment; it also assists the relatively insoluble potassium bicarbonate to remain in solution, so increasing the CO_2 that can be absorbed in the solution.

The plant has been designed to give an absorption efficiency of CO_2 and H_2S of over 90%; organic sulphur compounds such as carbon oxysulphide are hydrolysed to H_2S by the solution. Acid gases leaving the top of the regenerator consist of approximately 98% CO_2 and 2% H_2S.

After passing through an air-cooler — the condensate of which will be used to reflux and as a means of maintaining the strength of the solution — the acid gases will pass to the sulphur-recovery plant, where H_2S will be burnt first to sulphur dioxide, and then converted to sulphur, waste gases finally passing to a central chimney stack.

Construction

The absorber and regenerator vessels have been constructed of carbon steel and are unprotected internally; they are fitted with porcelain "Raschig" rings. The whole of the absorber and the lower part of the regenerator vessels are stress relieved.

The Benfield plants have been constructed with the vessels internally protected with either "gunited" concrete or resin-based coating, but the results do not appear to have justified the expense.

The sulphide skin that forms on internal metal surfaces when H_2S is present acts as a good protection agent, but where high velocities of carbonate solution occur, special precautions are obviously necessary, for the sulphide skin is torn away leaving the metal exposed to corrosive attack. Solids not filtered out will also give rise to erosion troubles.

Purification by Oxide

Although the Benfield plant gives an absorption efficiency of over 90% for CO_2 and H_2S, to purify the gas to statutory requirements, a further stage of purification is required before the gases pass to the main grid. H_2S content of gas at the outlet of the Benfield plant at Westfield is anticipated to be between 5 to 50gr. / 100 cu. ft. (i.e. equivalent to a concentration 100 to 1,000 gr. H_2S / 100 cu. ft. at the working pressure of 300lb. / sq. in.) depending on the sulphur present in the coal.

Choice of Bischoff System

For the final stages of H_2S removal at Westfield, the Bischoff system of oxide purification has been chosen. Whereas normal

*"Westfield High Pressure Coal-Gasification Plant" by T.S. Ricketts, presented at the 97th Annual General Meeting, Edinburgh, June, 1960.

oxide purification at low pressure is usually carried out on the backward rotation system when the last box in a series of about five boxes is placed first in the series by the operation of a number of suitably placed valves. This system, relying as it does on the correct sequence of valve operation and on tightness for satisfactory performance, cannot be regarded as foolproof. The Bischoff system for high-pressure purifiers, dispenses with box rotation and so eliminates the need for valves between boxes. In principle, the oxide is moved from one tower to another at specific intervals and the towers themselves always remain in the same fixed rotation (i.e. 1, 2, 3, 4).*

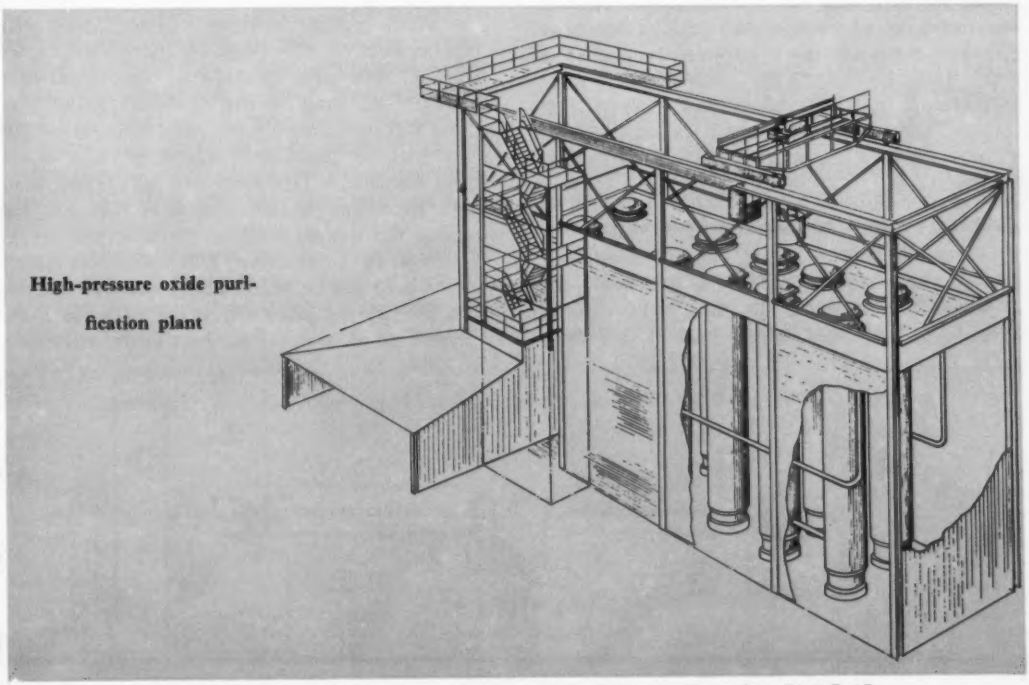
In using the Lurgi process where the oxide towers would be working at a pressure of 340lb. / sq. in., it would be an extremely serious matter if valves leaked on the towers. Inlet and outlet main to each main stream are provided therefore with two valves for double isolation purpose and the space between the two valves can be vented to atmosphere it if necessary.

Method of Operation

At Westfield two streams are being installed, each operating on the fixed rotation 1, 2, 3, 4. When it becomes necessary to effect a change, one stream can be shut off completely. Towers in the stream shut off can be opened; the oxide trays in tower I are removed and placed on the stacking form; the trays in tower 2 are then removed and placed in tower 1, those from tower 3 are removed and placed in tower 2, and those from tower 4 removed and placed in tower 3. This operation can be carried out in one day and the stream put to work again.

The period between oxide-changing operations is expected to be about 22 days on maximum load; the operation will be staggered so that one stream will be shut off every eleven days. The high-pressure gas contained in each stream will be vented to the lock gasholder before the system is purged with nitrogen prior to opening the towers.

Each tower is of mild-steel welded construction, being 46ft. overall height by 6ft. in



High-pressure oxide purification plant

*Designed and constructed by Newton Chambers and Co. Ltd. under licence from Bischoff AG.

diameter, with a shell thickness of 1 3/16in; the cover is of mild-steel and of the quick-operating type. Twelve trays of oxide are contained in each tower, these trays being of the double-layer detachable type to facilitate emptying (the Bischoff patent). The sides are made in two sections secured together by hasps and wedges; knocking back the wedges results in an increase in the circumference of the tray sides, which can then be lifted clear of the trays. A pivoted and rotating platform is provided for unloading the trays, the oxide from which falls through a grid into an oxide crusher. Labour requirements are estimated at two men for emptying and refilling up to eight trays a day with a five-day period for the change-over (one day for tower-changing operation, two days for emptying and refilling twelve trays from one tower and two days for oxide handling and disposal.

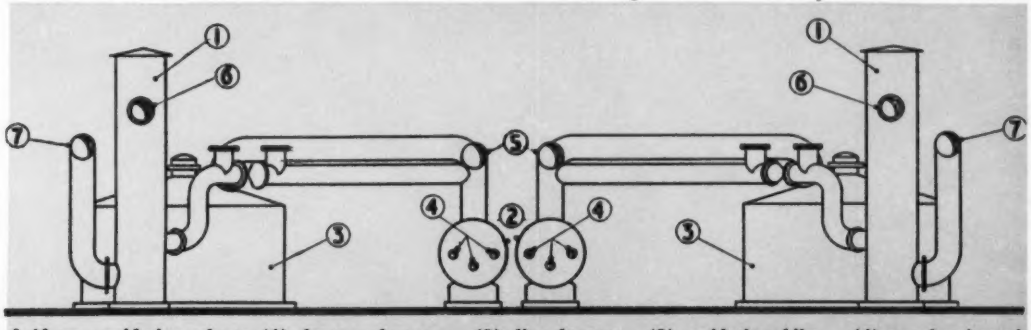
A controlled oxygen supply is provided at the inlet to each stream for revivification *(in situ)*, the quantity of oxygen to be admitted being determined by the concentration at the outlet of each stream. To prevent excessive deposition of moisture in the oxide, heaters are provided at each stream inlet. For heat retention purposes the towers are housed in a brick-clad building, for unless the inlet temperature can be substantially maintained through the towers, the water vapour formed as a result of the purification reaction cannot be removed.

Acid Gas Disposal and Sulphur Recovery

Some 10 million cu. ft. / day of acid gases will leave the regenerator of the Benfield plant and will contain about 1½% to 2% by volume of H_2S. It had been hoped that if H_2S were converted to SO_2, permission could be obtained for discharging the resultant gases to atmosphere, but in view of the concentration of sulphur and the high specific gravity of the gases, treatment of these acid gases was necessary. It has been decided that catalytic oxidation of H_2S, followed later on by recovery of sulphur by the Claus kiln catalytic process is the most suitable, the capital and operating costs being the lowest of all methods investigated. No sulphur-recovery plant has previously been operated on "lean H_2S" gases, however, but it is not considered that there is any reason why the process should not work satisfactorily at a recovery of about 80%, the remaining sulphur being discharged to atmosphere at SO_2. The end product at Westfield will be elemental sulphur.

During investigations into sulphur recovery from "lean H_2S" the Scottish Gas Board learned that the Gas Council's Fulham Research Station were carrying out experimental laboratory-scale work on the subject. Westfield and the Gas Council have collaborated in this work and a full-scale plant is to be designed and constructed by Simon-Carves Ltd.

Acid gases will be taken from the regenerator of the Benfield plant and, after cooling, will pass through an overhead steel main, 500ft. long, to the oxidation plant. The gases will pass a counter-current heat-exchanger and will be preheated against effluent gases from the plant. The preheated acid gases then pass to a line heater that uses fuel gas for raising the temperature of the acid gas to the optimum for conversion. Dilution air is added to the acid gas before it enters the lime heater, and the diluted gases are mixed with the combustion gases, which then pass to the oxidation



Acid gas oxidation plant. (1) heat exchanger (2) line heater (3) oxidation kiln (4) combustion air (5) dilution air (6) incoming gases (7) outgoing gases

kiln; this vessel is about 20ft. in diameter and contains a bauxite catalyst bed for converting H_2S and SO_2. The plant is designed to deal with acid gases having an H_2S content of up to 2.4% by volume and the necessary automatic controls are installed to enable fuel gas and dilution air to be varied accordingly. At all times there will be an excess of oxygen in the outlet gases from the kiln, and the temperature of gases to the kiln will be maintained at about the ignition temperature of the reaction; excessive temperatures that could lead to formation of SO_3 will be avoided.

The whole plant will be built in two parallel streams each capable of taking the whole load in stage I, thus allowing one stream to be taken out for maintenance. All equipment installed in stage I for sulphur oxidation will be incorporated in the final plant recovery of sulphur.

Future Outlook

The Gas Council has secured great economies by rationalising existing methods of production and ensuring that good yields of high-purity by-products are obtained where possible to offset gas maintaining costs. To achieve this, however, output is being concentrated on fewer and larger plants and newer methods of gasification have been necessary. Some 30 new plants have been installed to produce gas on favourable terms from the residual fuels and tail gases of the oil refineries thereby offsetting increases in labour and coal costs by some £15 million p.a.

Although there is increasing emphasis on liquid phase extraction and chemical sulphur recovery processes, iron oxide purification will continue to play a part, not only as a means of removing residual amounts of H_2S and organic sulphur compounds but also at the larger orthodox gas-making installation and their ancillary oil gasification and other economic gas manufacturing plants. In this respect, novel means of economic purification such as the Appleby-Frodingham fluid bed process can be expected to find increasing employment. Of prime interest, however, are the advances resulting from the application in the gas industry of modern chemical technology and engineering in the extraction of gas from coal by high-pressure process. The Westfield works constitutes Britain's first high-pressure plant for total gasification of low-grade coal. This £6½ million venture by the Scottish Gas Board must be regarded potentially as of the greatest significance. With the statutory demands of today with regard to sulphur content of gas, purification methods have advanced and at Westfield careful consideration has been given to these. The coals to be used at Westfield do not contain a high percentage of sulphur (around 1% sulphur) but other coals do. The new Coleshill plant, also to use Lurgi high-pressure gasification, will use coal containing as much as 3.5% sulphur.

The main significance of these two projects in that they are likely to be the forerunners of a series of major gasification plants each situated at a coalfield and linked to consumers by a national gas grid. Progressively they can be expected to result in the closure of all small gas works and possibly even some of the larger orthodox plants. It is too early to make an estimate of the impact of these projects on U.S. sulphur supplies. Westfield and Coleshill where sulphur is expected to be recovered in

Gas Available at Gas Works in Great Britain in the years 1954 to 1958, in Millions of Therms

	1954	1955	1956	1957	1958
Gas made:					
Coal Gas	2,027	2,082	2,083	1,991	1,885
Water Gas	402	384	354	314	410
Oil Gas	3	4	6	10	32
Other Gas	28	28	29	27	25
Total made	**2,460**	**2,498**	**2,472**	**2,342**	**2,352**
Gas bought:					
Coke-oven Gas	364	395	450	480	371
Refinery Gas	6	8	10	12	37
Methane	—	—	1	2	5
Total available	**2,830**	**2,901**	**2,933**	**2,836**	**2,865**

elemental form, will be capable of producing about 100 tons sulphur per day when in full operation. An annual supply of 100,000-120,000 tons by 1970 based on coal gasification is well within the industry's compass of ability.

The last named development is of particular importance to the gas industry which—consuming annually about 25 million tons of coal apart from about 28 million tons carbonised at coke ovens—remains overwhelmingly dependent on native coals as its raw material.

Unpurified coal gas contains 6 - 15lb. sulphur as H_2S per ton of coal carbonised. Hitherto purification has been almost exclusively dry using iron oxide boxes or towers. The value of the resultant spent-oxide—about 270,000 tons per annum containing up to 50% S, the bulk of which is consumed in sulphuric acid manufacture—has failed to keep pace with rising labour, materials, maintenance and, of course, capital charges. Total gasification offers favourable conditions for liquid phase sulphur extraction and this coupled with some of the other new alternative sources of gas supply, notably those based on oil gasification, are capable of contributing substantially to indigenous sulphur supplies either in the form of sulphuric acid or recovered elemental sulphur.

Micro-detection of Hydrogen Sulphide in High-pressure Sweet Gas Wells

THE problems of hydrogen sulphide embrittlement in the case of sour gas wells, especially where the gas occurs at high temperatures and pressures, such as is the case of Lacq, are well known. Stress corrosion cracking of well casing has occurred, however, in high-pressure gas wells which were considered to be "sweet," that is, free of hydrogen sulphide or direct analysis of gas samples. To investigate this matter, F. G. Rowe *et al.* of the Research and Development Department, Continental Oil Company, Ponca City, Oklahoma, conducted experiments designed to detect hydrogen sulphide, possibly present in extremely low concentration, by an indirect diffraction and microscopical method.

As copper has a high affinity for sulphur, it can act as a collector of hydrogen sulphide, if present in a natural gas well; copper "coupons," 8in. x 1in. x $\frac{1}{8}$in., were polished on a metallographic polishing wheel and then etched lightly in nitric acid to produce surfaces suitable for electron diffraction. Coupons of this type have been sent to gas fields and suspended in various so-called "sweet" wells for 15 to 30 days. Coupons after exposure were found to have tarnished or to have corrosion scales of varying thicknesses, but in all cases were less than 1ml. The corrosion scales were identified by electron and X-ray diffraction methods as cuprous sulphide (Cu_2S); thus establishing that there were trace quantities of hydrogen sulphide in "sweet" gas wells.

Especially suitable for identifying exceedingly thin corrosion scales is the electron diffraction method. For thicker scales X-ray diffraction is applicable since these scales if rough can fail to produce reflection-type electron diffraction patterns. X-ray diffraction can also detect tarnish when preferred orientation of the tarnish nuclei exists. In the present case, the same structure could be and was identified by the two techniques which provide also a basis for estimating the particle-size and morphology of the corrosion product.

The theory advanced that hydrogen sulphide is an agent of stress corrosion cracking can be regarded as being supported by the evidence of the Continent Oil Co. investigators. It is believed that on the basis of this theory more effective preventable measures such as inhibitors can be designed. In particular, collection of trace amounts of an active gas by allowing it to react with an active metal to form a crystalline compound can be considered to have useful application in many other systems.

U.K. Sulphur and Sulphuric Acid Consumption at Record Levels

Boom Conditions in First Quarter

IN the past months chemical industry in the U.K. has continued to make strong advances and chemicals are now the country's third leading export group. The boom conditions noted in the second half of last year have continued as is evident from this year's first quarter's results. All sectors of the sulphur industry has shared in the boom and this is reflected by the increased consumption of sulphur and sulphuric acid which has continued unabated and now stand at record levels.

Of the total consumption of sulphur raw materials 61% has been imported and the rest met by indigenous supplies. The main feature of the consumption pattern has been a steady rise of brimstone use and in the acid sector in the first three months of this year the effect of last year's acid installations has been reflected in the highest level of sulphuric acid production yet recorded. The acid industry as a whole has been working at nearly 90% of installed capacity.

Consumption. Total consumption in all forms amounted to 261,000 tons, of this 30,000 tons (22,100 tons) are imported brimstone and pyrites.

Imported brimstone use expanded from 81,117 tons to 96,103 tons in the two quarters (January to March 1959 and for the same period in 1960) since the greater part of additional acid requirements was met from production in contact plants, make at such plants rising from 499,230 to 572,689 tons between the two quarters noted. The first quarter's total of sulphur consumed for acid manufacture at 111,617 tons is 17.6% up on the first quarter of 1959 and up 2.4% from the last quarter of 1959 when the total was 108,049 tons. The acid industry as a whole has apparently been working at nearly 90% of installed capacity. Anhydrite consumption for the first quarter of this year has reached peak levels and stands at 193,318 tons, a 2.1% increase on the same quarter in 1959 when the total consumption was 189,338 tons, reflecting full employment of installed anhydrite acid capacity.

Pyrites use has also shown a significant advance (8.1%) with a first quarter total of 90,649 tons as against 83,835 tons in the same quarter in 1959. At an annual level of 362,596 tons this clearly reflects the increased level of activity, as does the very marked rise in usage of spent oxide (+11.7%) to 63,483 tons for the quarter and zinc concentrates up from 45,778 tons to 50,391—a 10% increase. Use of recovered sulphur from hydrogen sulphide and filter cake is also increasing.

SUPPLIES

Anhydrite. Supply of anhydrite for acid manufacture in the first quarter of this year, it will be noted, is 193,318 tons, a 2.1% increase over production during the same period in 1959. At the Casebourne Works anhydrite mine of Imperial Chemical Industries Ltd. at Billingham an all - time record production was achieved in 1959 with production at 1,082,571 tons. Since this mine began production in 1928, a total of 21,203,424 tons has been produced. I.C.I.'s mine modernisation programme appears to be going very well with the latest methods

Consumption of Raw Materials for Acid Manufacture

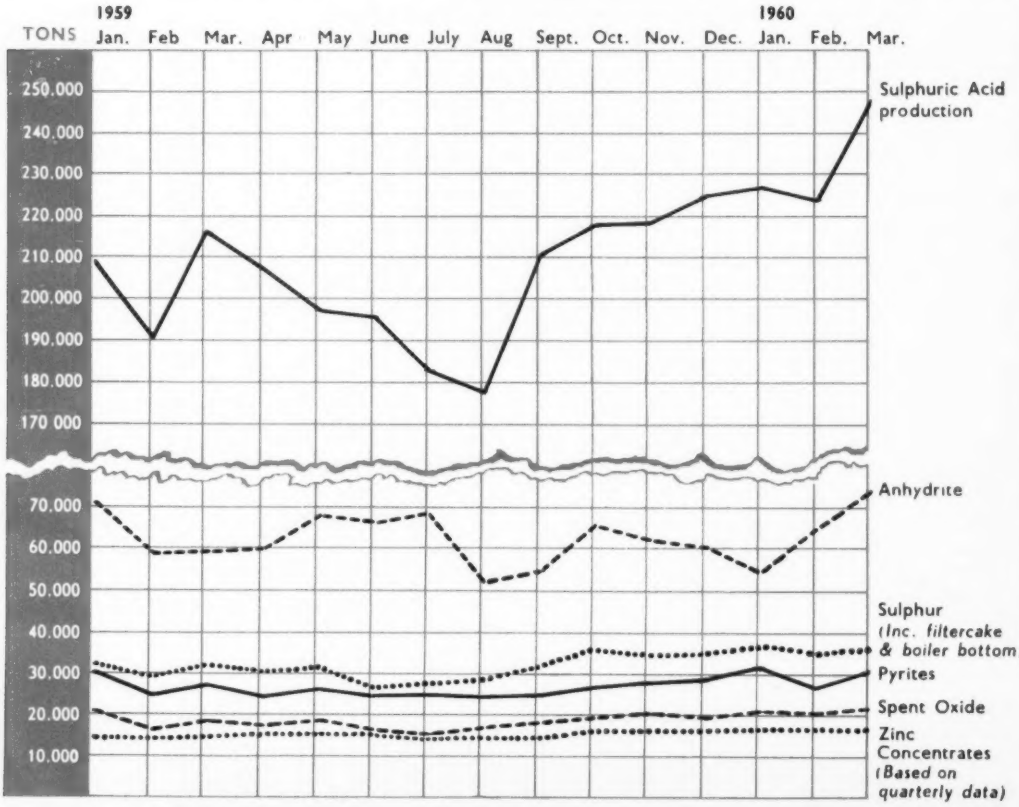
	1960 1st qrt.	1959 1st qtr.	% Change	1959 4th qtr.	% Change
Elemental Sulphur for Acid	**111,617**	**94,842**	**+17.6%**	**108,049**	**+2.4%**
Imported	**96,103**	**81,117**	**+18.4%**	**93,594**	**+2.7%**
Recovered H_2S and filter cake	**15,514**	**13,725**	**+ 1.3%**	**14,455**	**+ .7%**
Pyrites	90,649	83,853	+ 8.1%	84,930	+6.7%
Spent oxide	63,483	56,827	+11.7%	59,930	+5.9%
Anhydrite	193,318	189,338	+ 2.1%	188,314	+2.7%
Zinc concentrates	50,391	45,778	+10.0%	49,759	+1.3%
Sulphur Content of Materials used in Acid Manufacture	**240,900**	**215,400**	**+11.8%**	**231,600**	**+3.9%**
Estimates of Regular Sulphur Consumption	**28,000**	**24,000**		**26,000**	

and machinery in use. With imported brimstone supplies easily available future development of the Billingham mine has been under active consideration.

In a review of the mine's activities and the part it plays in I.C.I.'s raw material supply for chemicals and fertilizers, Mr. E. A. Blench, Billingham Division Production Director, foresees that anhydrite requirements by the company will remain as high as they are at present. In view of the lesser emphasis on ammonium sulphate manufacture from anhydrite, carbon dioxide and ammonia at I.C.I., expansion in this sector is unlikely. Billingham Division Technical managing director, Mr. W. d'Levy has also spoken about I.C.I.'s anhydrite mine and ammonium sulphate recently. When first established Billingham had the advantage of the large anhydrite deposit and this had enabled the division to make ammonium sulphate more cheaply than other producers. Over the years I.C.I. have made big advances in the mining of anhydrite. Compared with some years back the mine is now much more efficient and yet it has not been enough. Other people using other materials and other methods are converting ammonia into ammonium sulphate almost as cheaply as we can. The next five or ten years should see a still further improvement in I.C.I.'s mining methods.

Spent Oxide. Contrary to expectations, consumption of spent oxide totalled 63,483 tons compared with 56,827 tons in the first quarter of 1959, an increase of 6,656 tons (11.7%). The gas industry, however, has continued to experience considerable difficulties in disposing of spent oxide including the high grade over 45% S content, and the contribution made by sales is not offsetting purification costs.

Recovered Sulphur. Greater use of recovered sulphur is also noted, 15,514 tons as



against 13,725, a 1.3% increase over the 1959 level.

Current production at sulphur recovery plants is running at about 60,000 tons a year, an increase on last year's first quarter. Capacity for recovered sulphur is estimated at around 100,000 tons a year.

Production started at the new hydrodesulphuriser at Shell Petroleum Co.'s Shellhaven refinery on May 16. This plant is a 20-tons-a-day sulphur recovery plant which extracts sulphur from refinery gas. As the plant has only just come on stream the tonnage recovered has not reached 20 tons a day.

Output from the new recovery plant at the British Petroleum refinery at the Isle of Grain which has been in operation for some months past has within recent weeks been stepped up. Also working at an increased rate are the two recovery units of Esso Petroleum Co. at Fawley. Capacity for recovered sulphur is 28,000 tons high purity brimstone.

No new sulphur recovery plants are projected at the present time. The second hydrogen sulphide and sulphuric acid plant proposed for the Corby works of Stewart and Lloyds has been postponed.

IMPORTS

Brimstone. During the first quarter of 1960 imports of brimstone have shown a marked increase from 76,738 tons in the 1959 quarter to 128,784 tons. The apparent rise of 67.7% disguises the fact that in 1959 stocks were being reduced and were much below the level of usage whereas in the first quarter imports somewhat exceeded current 1960 consumption. By far the greatest change is shown in the imports of recovered sulphur from France which have risen from 80 tons in the first quarter of 1959 to 27,702 tons. Imports of brimstone from Mexico have also expanded by 56.5% from 15,329 tons to 24,012 tons. The United States share of U.K. brimstone imports in this latest quarter was 77,030 tons as against 61,304 tons in 1959—an increase of 25.7%. The ratio of imports from these three sources of supply is at present U.S.A. 59.8%, France 21.5% and Mexico 18.7%.

The average import value was £10 10s. 0d. a ton, a decrease of 8s. compared with the corresponding period in 1959.

United Kingdom Imports

	1959 1st quarter	1960 1st quarter	% Change
SULPHUR:			
DENMARK	1	—	—
BELGIUM	24	40	+66.6%
FRANCE	80	27,702	+
UNITED STATES ...	61,304	77,030	+25.7%
MEXICO	15,329	24,012	+56.5%
WEST GERMANY ...	—	—	—
Total	**76,738**	**128,784**	**+67.7%**
SULPHUR WASTE:			
UNITED STATES ...	4,510	1,502	−66.6%
PYRITES:			
CYPRUS	28,282	39,141	+38.4%
CANADA	4,191	—	—
IRISH REPUBLIC ...	210	—	—
SPAIN	20,001	2,364	−88.3%
Total	**52,684**	**41,505**	**−21.1%**

Pyrites. Pyrites imports at 41,505 tons representing a little over half of current consumption were 21.1% less than the quantity imported in the first quarter of 1959. The chief exporter of pyrites to the U.K. has again been Cyprus, who has further strengthened her position. Imports of pyrites from Cyprus totalled 39,141 tons in the first quarter this year compared with 28,282 tons in 1959, an increase of 38.4%. The only other source of pyrites supplies in the first quarter of this year has been Spain with 2,364 tons, a decrease of 88.3% from the 20,001 tons in the same period in 1959.

The average import value decreased from £6 a ton to £5 6s. 0d. in the same period in 1960, due to reduced f.o.b. prices, and lowered freight costs, now as yet from Sweden, due to seasonal factors.

Acid Industry

Sulphuric Acid Industry. During the first four months of this year sulphuric acid and oleum output (in terms of 100% H_2SO_4) reached a total of 700,200 tons as against 615,500 tons in the same period last year, an increase of 13.87%. Expansion in production was again almost wholly in contact plants, with output rising from 499,230 tons in the first quarter 1959 to 572,689 tons in the two quarters under review. Totalled installed capacity at 761,430 tons is markedly greater than at any time while the industry's working at nearly 90% (89.7% actual) was the highest level reached for over two years. Contact plants installed capacity in the first 1960 quarter when contact acid represented 82% of total make

totalled 621,850 tons and 92.1% of capacity was in use. Chamber and tower installed capacity was 139,580 tons with 78.8% in use.

Percentage of Acid Make from various Raw Materials

	1st quarter 1960	1st quarter 1959
Total elemental	**47.3**	**45.0**
Imported sulphur	**41.0**	**38.8**
Recovered H_2S and filter cake	**6.3**	**6.2**
Pyrites	17.4	18.0
Spent oxide	12.3	12.3
Zinc concentrates	6.2	6.3
Anhydrite	16.8	18.4
	100.0	**100.0**
Total acid make	**682.7**	**610.7**

Consumption of Acid. Consumption of sulphuric acid advanced in line with the general increased industrial activity and resulted in considerable growth consumption of acid to 700,193 tons 100% H_2SO_4 in the first quarter this year. This compares with 615,480 tons in the same quarter in 1959 (13.8%). Maintaining their lead among the consuming outlets were superphosphates and other phosphatic fertilizers which took 168,136 tons of acid or 24% of the total use. The greatest rate of expansion has continued to be in the titanium pigments industry which in the recent quarter took 115,241 tons of acid, 16.46% of the total, and 30,000 tons more than January-March quarter 1959. Compared with the first quarter in 1959 acid consumption in titanium dioxide manufacture has increased by 29,242 tons or 34%. Also showing a marked rise in acid usage are the metals industry with consumption up by 7,700 tons (26.1%), dyestuffs and intermediates up by 5,500 tons (25.9%) and rayon, and, reflecting the healthier state of this industry than of late, cellulose film up by 9,400 tons

Consumption of Sulphuric Acid and Oleum

'000 TONS

	1st quarter 1960	%	1st quarter 1959	%
Fertilizers	244.3	34.9	235.5	38.2
Superphosphates	**168.1**	**24.0**	**163.6**	**26.5**
Ammonium sulphate	**76.2**	**10.9**	**71.9**	**11.6**
Titanium dioxide	115.2	16.5	86.0	13.9
Chemicals	71.2	10.1	68.4	11.1
Rayon & Cellulose film	75.5	10.8	66.1	10.7
Metallurgy	37.2	5.3	29.5	4.8
Soap, Glycerine and Detergents	30.9	4.4	32.8	5.3
Oil Refineries	18.5	2.6	15.2	2.5
Dyes	26.7	3.8	21.2	3.4
Plastics	15.0	2.1	10.4	1.7
Miscellaneous	65.7	9.5	50.4	8.4
Total	**700.2**	**100.0**	**615.5**	**100.0**

(14.2%). Rayon usage in tyre cord has increased, while developments in packaging have resulted in greater demand for cellulose film. Now in full operation at Barrow are the new works of Transparent Paper Ltd. Other important changes, though quantitatively smaller, were recorded for agricultural purposes (+77.1%), bromine (+60.2%), phosphates (+98.5%), plastics (+45.2%) and textiles (+65.5%).

The apparent decline in acid usage for detergents does not represent the strength of this sector of U.K. chemical industry. The acid requirements for liquid detergents which have shown the greatest demand in recent months are embraced in the section headed "Miscellaneous uses" which will be noted as having increased substantially.

Major Changes in Acid Consumption compared with 1st Quarter 1959

TITANIUM DIOXIDE	115,241	+29.242	34.0%
SUPERPHOSPHATE	168,136	+ 4.530	2.8%
DYESTUFF AND INTERMEDIATES	26,697	+ 5.500	25.9%
RAYON AND CELLULOSE FILM	75,499	+ 9.400	14.2%
METALLURGICAL INDUSTRIES	37,198	+ 7.700	26.1%

Non-acid Sulphur. Non-acid sulphur appears to have increased to a level of 28,000 tons, approximately 4,000 tons more than in the corresponding period in 1959. This is attributable to the increased demand for manufacture of carbon disulphate. Actual consumption of CS_2 has been even greater, however, bearing in mind the recovery of approximately one-third of the throughput of Courtauld's Greenfield plant. Increased production of sulphur dioxide and hydrosulphites as well as greater demand by the rubber industry has contributed to the higher level of non-acid brimstone use.

New Plants. As has been expected, Laporte Titanium Ltd. are again extending their sulphuric acid facilities at Grimsby with a 300-tons-a-day acid plant to be built by Simon-Carves Ltd. Development of Laporte titanium is the chief project of a number to meet the needs of the company's next phase of development at the titanium company's works at Stallinborough which are estimated to cost £3.5 million and will increase T_iO_2 pigment output from 30,000 to 50,000 tons a year.

In the fertilizer industry, in addition to the expansion of fertilizers mentioned for Fisons, the Farmers Co. are also having a new 50 tons/day unit at Brigg. This plant will be built by Simon-Carves Ltd. and the acid is believed to be required for complex fertilizers.

Modifications have now been effected at the Hapton works sulphuric acid plant of William Blythe and Co. Ltd. and the plant, a B.A.S.F. fluidised bed roaster, the first to be built outside Western Germany, is now in production after having been closed for many years. The company are to make every effort to secure outlets for the increased production.

Courtaulds Landmark recovery process has now been operating satisfactorily for some time and it can be expected that wider application to other works of the company will increasingly affect net sulphur needs of this sector of the industry. Sulphur demand for CS_2 uses may be expected to increase with the continued increase in demand for rayon and cellulose film.

Among chemical uses of sulphuric acid to-day is production of hydrofluoric acid which has increased by some 30% on the 1958 level. Additional plant capacity for hydrofluoric acid to meet the increasing sales demand, is under construction at a major producers, Imperial Smelting Corporation Ltd.

Sulphuric Acid and Fertilizers

Next to the United States the proportion of H_2SO_4 consumed by the U.K. fertilizer industry is the lowest in the world. In view of the trend of industrial expansion it must be expected that the importance of H_2SO_4 usage in the fertilizer sector will decline still further.

In absolute terms, however, H_2SO_4 demand for fertilizer which in 1959 totalled 840,000 tons continues to rise. Thus in the first quarter 1960 superphosphates consumption of acid was 2.8% more while that for ammonium sulphate increased by 6%.

In recent reviews of the fertilizer industry superphosphates take nearly 35% of acid consumed. The overall change, however, in the first quarter of 1960 compared with the corresponding period last year is not great—an increase of 2.8%.

Total consumption of phosphatic fertilizer amounted to 304,000 tons, 247,000 tons of which were represented by superphosphates, compared with the preceding fertilizer year, whereas consumption of single superphosphates declined. This was offset by the increase in triple superphosphates used.

Consumption of water-soluble P_2O_5 was 16.6% higher than the average for 1952/55. Water insoluble P_2O_5 contained in ground rock and basic slag, the latter representing 98,100 tons P_2O_5, has declined by 1.3% in the corresponding period.

In the absence of exports from the U.K. of phosphatic fertilizers and the negligible import of water-soluble material (1958-1959 1,300 tons triple superphosphate) the H_2SO_4 requirements of the industry are directly influenced by the domestic changes in the use of single and triple superphosphate—thus, since 1955/56 manufacture of single superphosphate has declined from 198,800 tons P_2O_5 to 139,200 tons P_2O_5. At the same time triple superphosphate expanded from 32,900 tons to 60,200 tons and P_2O_5 in complex fertilizers expanded from 29,300 tons to 61,100 tons.

Of the total of 321,000 tons of N consumed in 1958/59, it is estimated that 200,000 tons N was represented by ammonium sulphate. Compared with the average for 1952/55 N consumption has increased 31.2%. The comparable increase for ammonium sulphate use appears to be similar, if not a little higher.

Plant Food Ratios and Compounds

Usage of P_2O_5 in the U.K. has been relatively much higher in past years than N and K_2O which recently, however, have nearly caught up. Thus the N : P_2O_5 : K_2O ratio of the nutrients has changed noticeably from 1 : 1.43 : 1.08 in 1952/59 to 1 : 1.20 : 1.17 in 1958/59. This levelling off in demand for superphosphate is important when considered in relation to sulphuric acid consumption and requirements of the fertilizer industry. These changes have been accompanied by an increase in the use of compound fertilizers.

In the swing from straight to compound fertilizers it is noted that this is most clearly marked in the case of water-soluble P_2O_5, 91% of which was applied in compound form in 1958/59 compared with 82% in 1952/55 and less than 33% in 1945/46. While straight sales of superphosphates fell rapidly from 1952/53

to 1954/55 their decline has not continued at the same rate either in absolute terms or as a percentage of total P_2O_5 consumption.

Average concentration of P_2O_5 in compounds consumed in U.K. 1952/5 to 1958/9

Season	Product (1,000 tons)	P_2O_5% Water soluble	P_2O_5% Water insoluble	N
1952/5 ...	2,010.9	8.60	1.77	6.72
1957/8 ...	2,365.8	9.24	1.36	7.84
1958/9 ...	2,395.0	9.39	1.29	8.55

Besides the change in the ratio of N : P_2O_5 : K_2O in fertilizer compounds there must be borne in mind where and for which crops demand for fertilizers is greatest and likely to increase most in the future.

Temporary grass acreages have expanded rapidly in recent years, and now receive higher average rates of nitrogen, potash and F.Y.M. (farm-yard manure) than any other main crop except roots and green crops and the third highest rate of phosphate after roots and permanent grass, yet only 43% of total acreages receives nitrogen, 40% phosphate, and 30% potash.

	N	P_2O_5	K_2O
Weighted overall average (cwt./acre) ...	.17	.25	.14
Average actual (cwt./acre)	.40	.60	.47

Compared with 1953, overall average rates applied to temporary grassland show a slight decline in phosphate. For permanent grassland, however, the average actual rates of total phosphate are higher than those for any other group except roots and green crops. Despite this, however, only 26% of permanent grassland receives phosphate. There is therefore scope for increased use of fertilizer on grassland in the U.K.

The progressive increase in compound fertilizers applications is most marked in the case of water-soluble phosphate of which in 1958/59 only 9% was applied straight compared with 15.9% in 1953-54.

Approximate proportion of P_2O_5 consumed by main crop groups in 1957/8 (1) and estimated proportion using 1957/8 rates (2)

Crop Group	P_2O_5 (1)	P_2O_5 (2)
Roots and green crops	32	16
All cereals	26	15
Temporary grass	18	19
Permanent grass	24	50

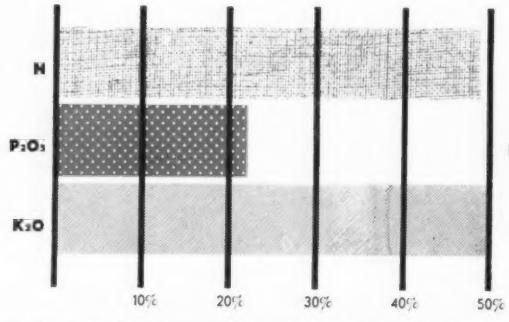
(1) Water insoluble (2) Water soluble

In the case of N, compound fertilizers represented 63% of total fertilizer use compared with 49.1% in 1953-54. Deliveries of ammonium sulphate for mixing represent 159,900 tons N of 49.8% of total N consumption in 1958-59.

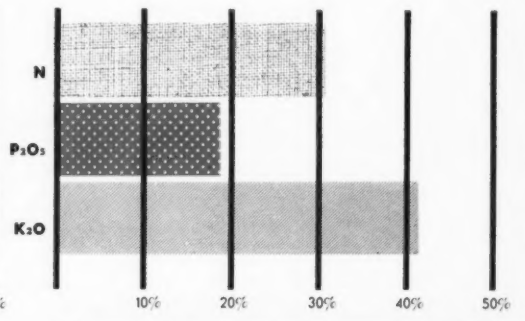
Outlook

The trend evident a year ago pointing to increased usage of brimstone in sulphuric acid manufacture has been accentuated and it must be expected that the present share of 47.3% will rise and reach 50% before the end of next year. Whereas in the immediate future the emphasis will be on imported brimstone the developments in coal gasification based on low-grade sulphurous coals indicate a substantial contribution after 1963 in the form of hydrogen sulphide which can be converted to sulphuric acid or elemental sulphur.

The consumption pattern will also be influenced by an expansion in anhydrite use resulting from the installation of a third kiln at Solway Chemical Works, whose anhydrite mine is developed to supply the needs of double the current anhydrite demand for the company's sulphuric acid manufacture.



% increase in consumption of inorganic fertilizers between 1952-55 and 1958-59



% increase in consumption of compound fertilizers between 1952-55 and 1958-59

That major developments are imminent in the sulphuric acid industry are indicated by the announcement that Fisons plan a new $1 million development at their Immingham plant which will step up production of phosphoric acid from June 1961. For the first time ammonium phosphate will also be manufactured following modifications to a plant now producing triple superphosphate. In this field an expansion of sulphuric acid must also be expected in connection with I.C.I.'s Belfast project.

Other sectors which continue to show a growth potential are titanium dioxide, rayon, cellulose film and steel. Increasing emphasis on recovery of waste acid and ferrous sulphate in pigments production will, however, reduce the net acid requirements of these industries. In 1960, it is expected that production and consumption of acid will reach 2.65 million tons and exceed 2.75 million tons in 1961. Installed capacity for acid production is being further expanded.

The function of the National Sulphuric Acid Association Ltd. in respect of purchasing and distribution of sulphur is being scrutinised by the Restrictive Practices Court. The Court has now started formal proceedings on the price-fixing arrangements of the imported sulphur pool.

In 1960 it is expected that brimstone imports will total 360,000 to 370,000 tons.

Prices and Trends

Boom in Brimstone Consumption

THE struggle for a larger share of world sulphur markets flared up again during recent weeks in some of the more competitive areas. With French recovered sulphur supplies virtually committed for the current year and Canada's not yet a significant market force, the competitive moves which took the form of price cuts, were made by United States of America and Mexican Frasch sulphur producers. Probably the largest consumer area so affected was Florida where prices declined by $1 to $25 giving the large fertilizer manufacturers in this area the lowest cost brimstone for about eight years. At the same time the level of world sulphur production has expanded under the stimulus of consistent demand. In Europe where sulphuric acid requirements are exceeding all previous records, brimstone consumption is booming, and pyrites, though to a significantly lesser extent, are benefiting. A contributory factor is the reduced incidence of by-product acid manufacture which in Belgium is occasioned by a shortage of zinc blende and particularly of lead ores.

In the U.S.A. despite the slackening of industrial activity and lower steel output rate sulphur consumption appears to be about 5% higher than last year. The growing chemical industries in Latin America, Africa and Asia, notably India, increasingly contribute to rising world demand which is currently estimated at an annual rate of close on 18 million tons sulphur in all forms.

The level of brimstone supply is at present slightly below the rate of consumption. The majority of consumers have reduced operating stocks at their works, and both in the U.S.A. and Mexico the level of Frasch sulphur producers' stocks has been decreasing. Notable exceptions are Canada where marketing difficulties and expanding gas cleaning operations are causing stocks to grow, and France where in keeping with rising output, Société Nationale des Pétroles d'Aquitaine is assigning a part of its output to create a modest stockpile. It is estimated that world stocks held by producers of brimstone are about 5 million tons, a decrease of about half a million tons during the past twelve months.

Pyrites supplies by European producers have also advanced under the stimulus of greater sulphuric acid activity throughout Europe. Although the current price of pyrites, which is to remain unchanged for the second half of this year, compares in general favourably with that of brimstone, producers remain uneasy with regard to their ability to hold their markets in the face of mounting competition from brimstone. In particular, the offers of financial aid to acid makers by some

brimstone suppliers, to ease the burden of capital outlay in conversion or new construction of acid plants, is held to be a serious threat.

Although the current overall supply position in world sulphur markets is statistically firm, the existing surplus capacity and the shadow of heavy new supplies of recovered sulphur from France and Canada, and probably also before long of refined sulphur from Poland, have an overwhelming effect on market sentiment and producers' price policy.

The competition among the leading producers, which manifests itself in progressive reduction of prices, appears to be primarily aimed at securing for themselves future markets. In so doing they fail to derive the benefit from existing markets which are continually expanding. Moreover, as is evident from its growth curve, the industry is becoming less narrowly based, as the number of sulphur users and the volume of output consumed throughout the world increases, thereby improving the conditions conducive to fairly applied price leadership.

The existence of surplus productive capacity is no novel experience for the industry, yet by pursuing the prevailing negative policies primary sulphur producers are being financially weakened to the point when the smaller producers are forced to close down, thereby opening the door for monopolistic tendencies which cannot fail in the long run to become a threat to the consumers. Of the various alternatives which the industry might apply to remedy its present state of affairs, the possibility of selling sulphur on an Exchange Market, as practiced for most other commodities, deserves consideration. In their recent half-yearly report, Aikman (London) Ltd., advocate a similar course for nitrogenous fertilizers. Although such a solution would apply primarily to world trade sulphur, exchange dealings would at least establish uniform world market prices with due regard to the present and the future, thereby providing to both producers and consumers safeguards which they at present lack.

PRICES

Brimstone

In the U.S.A. posted prices remain unchanged at $25 per ton for bright f.o.b./f.a.s. Gulf ports with a discount of $1 for off-colour grades and $1.50 for delivery ex-mine. In effect for all but a very small number of protected markets as a result of freight contributions of up to $3.50 basic prices to-day are $21.50 per ton f.o.b./f.a.s. for bright sulphur with corresponding discounts as indicated above. In Florida (Tampa area) where the sulphur price had been reasonably stable at $26 per ton, Texas Gulf Sulphur Co. reduced its liquid sulphur price in May by $1 to $25 for off-colour grade. This was immediately countered by a similar price cut by Pan American Sulphur Co. for both imported Mexican off-colour and acid treated grades. The impact of this may be far-reaching as hitherto liquid sulphur enjoyed a premium of $1 over bulk deliveries. As yet the delivered price along the Atlantic Sea board remains at $26.50 per ton. Whereas for December 1959, Mr. E. Walet Jr. president of Jefferson Lake Sulphur Co. is reported to have assessed the average price for all grades at $20.25 per ton f.o.b. mine recent reduction point to the 1960 average being at least 5% lower.

The price listed by Mexican sulphur producers is $23.50 per ton of acid treated yellow sulphur f.o.b. Coatzacoalcos. The effective current market price is similar to that of United States Frasch sulphur—$21.50 for bright and $20.50 for off-colour grades. In highly competitive markets, notably in Europe, additional discounts bring the net return to the producers below this level.

In Europe and a number of overseas markets, notably in South America and in India, competition is at present primarily between Sulexco selling on behalf of the U.S. Frasch sulphur producers and the Mexican suppliers. French recovered sulphur from Lacq, which in Europe enjoys a significant freight advantage has at present a lesser impact on prices as the 1960 saleable output is reported to be committed. Delivered prices in Antwerp/Rotterdam are reported at $24.50 per ton. In other European destinations prices range from $26.50 to $28.50 per ton. Delivered prices of bright sulphur at Calcutta have declined to $28 per ton and in some South American markets to $25 per ton.

Russian sulphur continues to be offered

in small parcels at competitive prices; in Belgium it is offered at $24.50 or fractionally less.

Domestic prices of recovered sulphur in European countries although based on the price level of imported sulphur, have so far been little affected by the decline of import prices. This is partly due to their embodying inland delivery charges, taxes, premium for special delivery, such as supplies in liquid form, etc.

In Western Germany prices in the Ruhr and at Hamburg of domestic brimstone recovered at oil refineries and the Ruhrgas A.G. range from DM 115-125 per tonne plus turnover tax plus handling and service charges. In Belgium recovered sulphur is sold at B. Frs. 1,250-1,350 and in Holland at DFl. 95-100. In France domestic prices rose Frs. 13,000-14,000, the freight charges to consumers being preequated. In Sweden domestic supplies by Svenska Skifferolji A.B. command a price of SFr. 158 per tonne; Orkla sulphur from Norway is priced correspondingly.

The price of recovered sulphur in W. Canada remains based on $23.50 ex-plant. Sold throughout W. Canada and entering increasingly the Pacific and N.W. United States, delivered prices range widely but remain competitive with U.S. Frasch sulphur which has been displaced. As yet there are no signs of an adjustment of Canadian rail freights, so that the Great Lakes market, where U.S. Frasch sulphur has freight advantages of $9-10, remains outside the economic radius of delivery of Canadian sulphur supplies.

Pyrites

The price level of European pyrites is to remain unchanged for the second half of this year. Rio Tinto and Tharsis crude fines price pyrites at 60s. per tonne f.o.b. Huelva basis 48%S for all values provides basis for price structure. Other Spanish pyrites are priced correspondingly within narrow limits but the differential for Rio Tinto 'Confines' flotation concentrates is 10s. per tonne less. Portuguese pyrites prices are based on 58s. per tonne f.o.b. Setubal basis 48%. Cypriot pyrites, the export value of which was 45s. - 55s. per ton, and Norwegian pyrites are priced competitively. Continuing high copper prices and strong ore demand by the iron and steel industry exert a favourable effect on pyrites residues values although the recent decision to lower German pig iron prices by about 10% acts as a brake. Current values on the Continent are approximately 80s. per tonne for cupreous residues, while for non-cupreous material of good quality 70s.-75s. per tonne f.o. barge Rotterdam is quoted.

The present low all-values prices and sea freights for pyrites and high residues returns provide acid makers with relatively very cheap sulphur in pyrites. On the basis of current prices pyrites delivered to major Continental ports represent a sulphur of value of about 8d. per unit whereas brimstone costs about 21d. This margin is appreciably wider than it was in the 1930's even when making allowance fof the present higher capital and operating costs of pyrites acid plants. The continuing practice on the part of practically all European pyrites producers of selling all values on an f.o.b. basis denies them the opportunity of establishing a fixed relation between delivered prices of sulphur in pyrites and brimstone. Moreover, through the Pyrites Residues Organisation the onus of the orderly disposal of residues rests on the pyrites producers who at the same time are no longer in a position to exercise direct commercial control over a major value in their product. The underlying source of the prevailing unease about their ability to compete with brimstone may well be found in this anomalous position which has its origin in the uncertain trading conditions of wartime and early post-war days.

SUPPLY

Brimstone

In the U.S.A. production of Frasch sulphur has been maintained at a level of about 430,000 tonnes monthly which is accompanied by a moderate reduction of stocks. The current rate of output represents the employment of only about 55% - 60% of installed capacity although the full capabilities of the new offshore dome of the Freeport Sulphur Co. are as yet untested. The volume of imports from Mexico and Canada is advancing at least as rapidly as rate of growth of domestic market which consumes about 4% - 5% more than last year. The level of Frasch sulphur stocks is approximately 5.7 million tons.

Pyrites

Pyrites
is the source of
a wide range
of other valuable
derivatives
serving many
industrial
needs

COMPAÑIA
ESPAÑOLA
de MINAS
de RIO TINTO S.A.

The Tharsis and
Rio Tinto mines in Spain
have supplied Pyrites for
over 80 years. Their known
reserves are unrivalled

THE THARSIS
SULPHUR AND
COPPER CO. LTD.

In Mexico production of Frasch sulphur 522,000 tons in the first half of 1960 at present averages 100,000 tons monthly—about 10% less than a year ago. Only Pan American Sulphur Co., representing about 80% of total output, and Gulf Sulphur Corporation are regular producers, as Texas Gulf Company's operations have ceased and those of Texas International Sulphur Company are sporadic. A small but rising volume of Frasch sulphur—probably 50,000 tons in 1960—goes into home consumption, while the U.S.A. still represents by far the largest outlet—over 65%.

Fused sulphur production in Italy has fallen back to just over 6,000 tonnes monthly of which about two - thirds originates from Sicilian mines and one - third from those on the mainland. Exports in the first two months of this year which included ground sulphur, mainly a major sale to Greece, amounted to 23,861 tonnes, while domestic users in this period received 11,366 tonnes, some 20% less than the average for the preceeding six months. Frasch sulphur stocks now total about 200,000 tonnes. Production of sulphur concentrates is at an annual rate of 30,000 tonnes and all, but about 10% used for the manufacture of polysulphides, are filtered and converted to CS_2.

The rate of opencast sulphur ore mining in Poland is reported to have increased to an annual rate of close on 1 million tonnes. New methods of sulphur extraction are replacing the ore treatment by flotation and filtering; the latter yielded a 72% recovery, whereas the new methods are claimed to extract 95% of the sulphur content of the ore which ranges from 17% to 40%S.

Sulphur sold by the U.S.S.R. in Western Europe in small quantities has been found to assay 99.1-99.2%S, 0.-15-0.18 bitumen, 0.3% moisture, 0.05 - 0.08 ash. The material is delivered in moulded cakes; it is slightly off colour, with a greenish-brown tinge, and has a strong petroleum smell. Although it resembles Frasch sulphur in some respects, it is believed to be derived from refined native ore.

In Iran the sulphur ore mining and refining project in Shiraz has been revived and is to be reassessed by the Ministry of Mines.

Recovered Sulphur

In the U.S.A. recovered sulphur production has fallen back slightly but as new plant capacity is being added, the upward trend of supplies to the home market continues and as previously estimated the 1960 output is expected to total at least 700,000 tons sulphur.

In Canada output is advancing slowly and is at present at an annual rate of about 450,000 tons. The rate of deliveries remains practically unchanged and stocks held at the various recovery plants are believed to be nearing 400,000 tons.

Jefferson Lake Petrochemicals whose U.S. parent company has completed the necessary financing arrangement, has now applied to the Alberta Oil and Gas Conservation Board for authorisation to build a $12 million gas cleaning plant and gas gathering system. Capable of treating 150 million cu. ft. of crude gas daily, the plant will also yield 863 t.p.d. brimstone.

At Lacq the level of production has risen and is now at an annual rate of about 1 million tonnes. The anticipated output for 1960 remains about 800,000 tonnes of which about 700,000 tonnes is to be delivered and the balance added to stocks. Gas pressure in the wells is reported to have dropped slightly in conformity with volume of gas extracted to date.

Several major lignite gasification projects, which are being developed in connection with power and N. fertilizer plants, also represent potential sources of recovered sulphur. The projects at Neyveli, S. India and Ptolemais, in Greece, are under construction and deposits near Kutahja, Turkey, and in Yugoslavia are being developed.

Pyrites

The level of European pyrites supplies has risen to meet the requirement resulting from the higher level of sulphuric acid production. The widespread employment of fluidised bed roasting favours supplies of nonarsenical ores and also calls for increased supplies of fines (2 mm. and less) and of flotation concentrates. Spain whose exports in 1959 totalled 1,025,736 tonnes maintained the improved rate of shipments evident in the latter part of 1959. Greece produced 113,303 tonnes pyrites in 1959 of which 27,410 tonnes was exported. This year exports of 60,000 tonnes are foreseen.

Exports of Cypriot pyrites during the first four months of this year totalled 354,372 tons of which 99,776 tons was in the form of cupreous pyrites. West Germany was the largest customer (64,752 tons) closely followed by the U.K. (63,365 tons); Belgium, Italy, France and the Netherlands accounted for the balance.

Deliveries of by-product pyrites in Canada in 1959 totalled 1,051,873 short tons (418,200 s. ton S content), about 12% less than in 1958 when they were the highest on record. The decline in exports was the main contributory cause. Booming sulphuric acid demand in all sectors of Canadian chemical industry, except for uranium ore treatment, is reflected by the continued expansion of by-product pyrite deliveries.

Strong demand by Japan's sulphuric acid manufacturers boosted pyrites production in 1959 to 3,423,037 tonnes and this year a further increase of at least 3% is expected.

In Venezuela the use of pyrite by Instituto Petroquimica has given way to brimstone. The pyrite deposit is reported to be exploited for its copper value only.

In Cuba Cia Buenavista S.A., which is exploiting the high cupreous pyrite and chalcopyrite deposits 45 miles West of Havana, is reported to have succeeded in developing a satisfactory method of flotation for this ore. Previously exported as crude ore, the output is now in the form of copper and pyrites concentrates the latter assaying 51-52%S.

FREIGHTS

The seasonal decline in freight rates became evident in May. Initially it affected only the trans-Atlantic trades notably in grain, and as these represent over one-half of volume of tramp chartering, the sulphur freight rates from Gulf of Mexico also dropped. Rates to the Far East have been less affected as the high level of imports into Japan has made a heavy call on available tonnage. As a corollary rates from the Pacific and from India have fallen sharply.

The rate for brimstone from the Gulf of Mexico to the U.K. declined from 52s. to 47s. 6d. Even to Manchester, a port which generally commands a premium, only 50s. had to be paid from U.S. Gulf ports while from Coatzacoalcos a fixture at 45s. was made. To the Continent rates have fallen back to $3.50 - $4.00 f.i.o. Rates from Bayonne to the U.K. which had hardened substantially earlier in the spring have remained firm based on 25s. f.i.o. for the East coast and 30s. f.i.o. for the West coast. To Continental ports rates from Bayonne have receded about 2s. to 18s. - 19s. f.i.o.

Pyrites to W. Europe from Huelva are reported at 25s. 9d. (2/6d. loading and 2/6d./2s. discharge. From Setubal charters at 24/10½d. on similar terms are reported. These rates are about 2s./2s. 6d. higher than those prevailing in May. From Cyprus to Rotterdam fixtures at 26s. and 27s. were reported in May, and from Quebec at 31s. (f.o.b. and 2s. discharge).

Rates for brimstone to India and Australia have remained virtually unchanged at $9.50 - $10 for India and 87/6d. - 91s. 3d. to W. Australia and 82/6d. to Eastern Australia. From Coatzacoalcos to Haifa, Israel, a charter of $87 (¢50 loading/free discharge) is reported. To Santos (Brazil) $5.50 f.i.o. was paid.

On balance freight rates are now about 4-5% higher than a year ago. During the summer months a further slight weakening of the freight market is expected. The anticipated sustained high level of activity in the European chemical and steel industries in the latter part of this year, points to a hardening of rates, but as in recent years the determining factor in the freight market will be the European harvest and the level of grain shipments.

DELIVERED PRICES

Posted f.o.b. Country of Origin		U.K.		N.W. Europe		India		Australia (E. Coast)	
U.S.A.	$24-25	(50s.)	£10½-10⅝	(34s.)	£ 8¼-10½	—	£10	(82s. 6d.)	£11½-12¼
Mexico	$20.50-23.50	(45s.)	£ 9⅝-10½	(34s.)	£ 8¼-10½	—	£10	(82s. 6d.)	£11½
France	—	(28s.-37s. 6d.)	£10⅝-11¼	(21s.)	£ 9⅛-10½	(42s. 6d.)	£10⅝*	(65s.)	£11¼*
Canada	$23.50	(57s. 6d.)	£11¼*	(42s. 6d.)	£10½*	(60s.)	£11⅛*	(42s. 6d.)	£10½*
Italy	L18,000	(30s.)	£12*	(25s.)	£11⅛*	(42. 6d.)	£12½*		—

*Notional

United States Sulphur Industry

1st quarter's results show record domestic consumption

U.S. BUSINESS is reported as having weathered stock adjustments well. Consumer markets have been strong and business investment in new plant and equipment is increasing. The considered opinion is that there will be a renewed, albeit moderate, advance in general business activity.

With regard to the first quarter's results in the U.S. sulphur/sulphuric acid industry this has to a certain extent been affected by the decline in industrial production (1.8%) from January to March. A sharp reduction in stocks has had a particularly heavy impact on the U.S. steel and motor car industry. Steel operating rate dropped from 95% in January to 74% in early May. Production is believed to have levelled out in April as continued strength in other industrial sectors offset the falling off in steel and cars. Steel output is unsteady around the 60% capacity mark.

Frasch Sulphur

During the first quarter 1960, production of Frasch sulphur amounted to 1,366,255 long tons compared with 1,202,895 tons during the first quarter of 1959, an increase of 13.5%. Compared with the fourth quarter's total of 1,303,095 tons, production has increased (4.8%) but output of Frasch sulphur continues to be restricted by U.S. producers. In contrast to last year's planned run-down of stock, currently production is kept in line with requirements; these appear to exceed the level of sales indicating stock formation away from the mines at distribution centres.

There are at present thirteen sulphur domes in operation and the restrictions to output apply primarily to the two large producers, Texas Gulf Sulphur Company and Freeport Sulphur Company. An increasing proportion of production is being distributed in liquid form.

Apparent sales of Frasch sulphur in the first quarter amounted to 1,190,877 tons compared with 1,154,426 tons for the corresponding quarter in 1959, a rise of 36,451 tons (3.1%) but 117,445 tons less than the last quarter of 1959.

This reduction is attributable mainly to the lower level of exports of Frasch sulphur compared with the fourth quarter of 1959, when this was exceptionally high.

Frasch stocks amounted to 3,810,348 tons at the end of the first quarter 1960, having remained virtually unchanged. Compared with the stock position at the end of the first quarter of 1959, when they amounted to 4,325,410 tons, the reduction is substantial — in excess of one-half millon tons. The bulk of the reduction occurred during the second half of last year and all main United States producers were recording that stockpiles were being reduced; Texas Gulf Sulphur Company, for instance, record a reduction of 8% for 1959 of their stockpile.

Comparison of 1st Quarter 1959-1960

Sulphur Production

Long Tons	1959	1960	tonnage change	change
Production total ...	1,202,895	1,366,255	+163,360	+13.5
Frasch ...	1,037,770	1,191,517	+153,747	+14.8
Recovered ...	165,125	174,738	+ 9,613	+ 6.5
Apparent consumption	1,173,263	1,211,211	+ 37,948	+ 3.2
Apparent Sales ...				
Frasch ...	1,154,426	1,190,877	+ 36,451	+ 3.1
Recovered ...	165,145	191,971	+ 24,732	+14.9
Total stocks	4,502,937	3,933,361	−569,576	−12.6
Frasch ...	4,325,410	3,810,348	−515,062	−11.9
Recovered ..	177,527	123,013	−554,514	−30.6
Change in stocks ...	− 116,400	−16,593		
Frasch ...	− 116,656	+ 640		
Recovered ...	+ 265	−17,233		
Total imports	131,994	181,162	+ 49,168	+37.5
Total exports	278,026	352,799	+ 74,773	+26.8

Recovered Sulphur

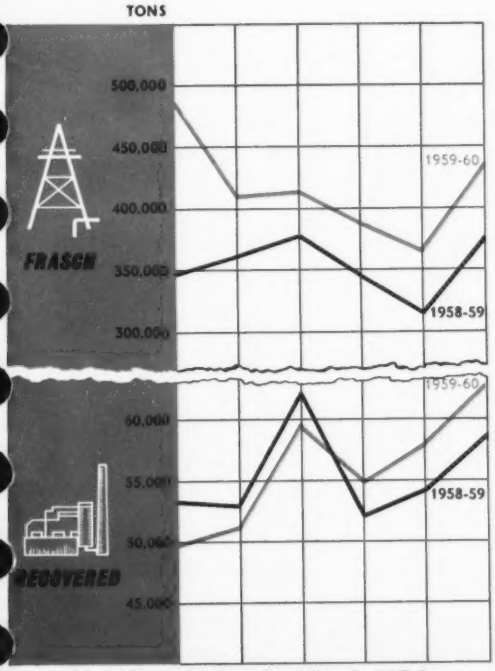
In this first quarter of 1960, expansion in the production of recovered sulphur has continued from the 161,628 tons recovered in the last quarter of 1959 to reach a total of 174,738 tons. Compared with the first quarter of 1959 when the total recovered was 165,125 tons this is an increase of 6.5%.

Apparent sales of recovered sulphur for the first quarter of this year amount to 191,971 tons, 16.3% more than in the corresponding period in 1959 when the total recovered was 165,145 tons.

With the recently completed recovery plants in the United States and some further ones due in operation shortly, additional capacity of 200,000 tons will be available this year and production of recovered sulphur is expected to continue increasing.

Now operating (or expected on stream within the next few weeks) is the 12½ tons a day sulphur recovery plant of Pan American Petroleum Corp., at Abo Field.

The high level of deliveries has caused stocks of recovered sulphur to be reduced in the last few months. At the end of the first quarter of 1960 stocks amounted to only 123,013 tons, a fall of 54,514 tons or 30.6% compared with the same time last year.



Monthly production of sulphur in U.S.A.

Trade

Imports of sulphur by the United States during the first quarter of 1960 amounted to 181,162 tons compared with 131,994 tons in the corresponding quarter of last year, an increase of 37.5%.

Increased imports have originated mainly from Mexico but Canadian sulphur is increasingly making itself felt in the United States' north-west. Part of the increased imports from Mexico contributed to the build-up of stockpile at the new sulphur terminal of the Pan American Sulphur Co. at Tampa, but a sizeable expansion of sales to the U.S. market has also taken place.

Exports in the first three months of this year have risen to 352,799 tons, 26.8% up on the corresponding period in 1959 when 278,026 tons were exported. The United Kingdom and Brazil were the largest export markets; the tonnage shipped to the U.K. (81,151 tons) represented a large increase of 36,886 tons, whereas shipments to Brazil 40,795 tons decreased 1,789 tons. Third largest market was West Germany which took 22,331 tons, an increase of 8,081 on the 1959 period. Despite the absence of deliveries to the Freeport nickel refinery which closed early this year Cuba remained a good market, taking 15,000 tons in the first quarter this year compared with 3,310 tons in the corresponding period in 1959, a change of 11,690 tons.

United States exports strengthened their position in the Netherlands and during this first quarter of 1960, amounted to 15,979 tons compared with none in the corresponding period in 1959. This coincides with the rapidly developing Dutch chemical and fertilizer industries. Also a good market was Belgium with an increase of 16,864 tons to 26,264 tons. The French market deteriorated as was expected and shipments to France at 20,610 tons were down by 9,610 tons,

Examination of the distribution of export destinations in the first quarter of 1960 shows the importance of Western Europe as an export market for U.S. sulphur.

Sulphur Exports from U.S.A.

	1960	1959
	%	%
North and Central America	8.6	9.3
South America	14.6	16.7
Western Europe	49.7	36.7
Australasia	11.6	16.0
Asia	8.6	8.0
Rest of World	6.9	13.3

Consumption

Deliveries of United States Frasch sulphur to the domestic market during the first quarter of this year have been somewhat higher than industrial activity would suggest; amounting to 1,211,211 tons as against 1,173,263 tons in the corresponding quarter of 1959 these are 37,948 tons (3.2%) higher.

Domestic elemental sulphur consumption has been running at a record level, however, in the early months of 1960. Led by rubber manufacturers, non-acid sulphur-consuming industries such as paper and rayon, increased their usage. Sulphuric acid manufacture has shown strong demand and noted as taking more acid in the first quarter of this year are iron and steel pickling, phosphoric acid, superphosphates, ammonium sulphate, hydrofluoric acid, aluminium sulphate, petroleum refining, chemicals, detergents and uranium and other applications.

Sulphuric Acid

Production of sulphuric acid in the first quarter totalled 4,710,305 tons (100% H_2SO_4) compared with 4,450,439 tons for the corresponding quarter of 1959, representing a rise of 5.85%.

Since the last half of 1959 most sectors of the industry have been operating at a high level. This follows the rise in steel production

Sulphuric Acid Production

Short Tons 100% H_2SO_4

1960	Jan.	Feb.	March
Gross Total ...	**1,589,402**	**1,501,848**	**1,619,055**
Chamber ...	194,941	179,641	198,961
Contact ...	1,394,461	1,332,207	1,420,094
Spent Acid ...	62,848	65,838	69,720
1959			
Gross Total ...	**1,464,274**	**1,406,287**	**1,579,878**
Chamber ...	189,420	181,030	193,464
Contact ..	1,274,854	1,225,257	1,386,414
Spent Acid ...	51,161	48,745	58,314

following the strike last year. The steel industry in the last few weeks, however, has shown some recession. The needs for the fertilizer industry have not exerted as much pressure on acid supplies as might have been expected since the U.S. fertilizer season has been affected by adverse weather conditions.

New U.S. Acid Plants

More sulphuric acid capacity is on hand in the United States with the expansion of Pittsburgh Chemical Company's sulphuric acid plant at Neville Island, Pennsylvania. This has boosted the company's capacity by 70%, and is now estimated to total 150 tons a day.

Continuing with their modernisation programme E.I. Du Pont de Nemours and Co. Inc., have awarded a contract to Chemical Construction Corporation to design a single train sulphuric acid plant to produce up to 1,000 tons a day. The plant will be at Du Pont's La Porte, Texas, facilities and is due to be completed in 1961.

Sulphuric acid upgrading is to play an important part in future plans for Dixon Chemical and Research Inc., it is learned. The initial phase is the just completed $1.5 million aluminum sulphate plant at Newark, New Jersey, which will take 20,000 tons of sulphuric acid a year. An affiliate, Dixon Chemical Industries Ltd., plans to build a hydrofluoric acid plant at Paulsboro, New Jersey, which will use 30,000 tons of sulphuric acid a year.

Following the start-up of their new multi-million dollar mining facilities at Galveston, Texas, United States Sulphur Corporation have now announced plans for construction of a $6 million sulphuric acid plant at the new Galveston plant to be completed by this year.

Outlook

United States domestic use can be expected to establish a new record in 1960 although steel at the time of writing is running at about 60% capacity and may settle still further.

The sulphuric acid industry has certainly been affected by the persistent down turn in steel production following the 80% capacity levels at the start of the year, but in general, sulphuric acid production and consumption

continue to show steady growth. Output and use for the first quarter of 1960 are greater than for the 1959 period.

Generally, the United States sulphuric acid industry is optimistic that production and consumption will reach new high levels in the first half of the year and that gross output for the year will be well over 18 million short tons (100% H_2SO_4), about 4% over 1959. Total capacity of 22.6 million short tons at the beginning of the year, however, is still about 20% above production levels. Profit margins have been narrowed because of the severe competition in the number of regions, rising costs of manufacture and distribution. This has meant substantial but unvarying discounts under list at many shipping points.

United States sulphur exports have done extremely well during the first quarter of this year as a result of the forceful world-wide policy of Sulexco. Although there have been some significant changes in markets the current year's exports are likely to reach a new peak.

The prevailing policy of the U.S. Frasch sulphur producers to restrict output to conform with sales in order to prevent build-up of present stocks can be expected to continue. In view of the increased capacity, however, especially the new domes which came into operation within the last twelve months, this policy runs counter to the U.S. producers' endeavour to increase profitability.

With continued competition from Mexican sulphur in the home market, the starting up of significant operations in Canada and sulphur recovery at Lacq, France, soon to be 4,000 long tons a day, the United States sulphur industry is faced with declining profits, which threaten to impair its ability to continue exerting a leading influence in world sulphur affairs.

Successful First Quarter for Mexican Sulphur Producers

FROM one point of view the first quarter of the year was undoubtedly a successful period for the Mexican sulphur producers. As compared with the first quarter of 1959, both the Pan American and Gulf Sulphur companies sold considerably more both to the export and home markets; and Petroleos Mexicanos achieved higher sales to the domestic consumers. Total deliveries rose by 49% to some 388,000 tons, the increase being spread fairly evenly over existing markets. However, when considered from the viewpoint of production, the period presents a different aspect. In contrast with the historical upward trend, the output of Frasch sulphur actually fell by 8% to about 285,000 tons. The Gulf Sulphur Company produced at a somewhat lower rate than in the corresponding period of the previous year; the Texas Gulf Sulphur Company's plant at Nopalapa was closed in February; and the Texas International Sulphur Company's Texistipec Dome, though long expected on stream, has not in fact yet emerged from preliminary testing operations.

Frasch Sulphur

Pan American Sulphur Company. Striking advances were achieved in both the export and domestic markets:—

	First Quarter ('000 tons) 1958	First Quarter 1959	Change	%
Production ...	207.0	212.5	+ 5.5	+ 3
Exports	187.1	261.9	+74.8	+40
Domestic Sales ...	6.5	7.6	+ 1.1	+17
Total deliveries ...	193.6	269.5	+75.9	+39

Shipments exceeded production by some 57,000 tons and the Pan American Sulphur Company's stocks now stand at about 523,000 tons. Run of the mine sulphur contains 0.23 - 0.25% carbon, but filtered material is 0.05% carbon and 99.9% sulphur. The output of filtered brimstone—in which acid treatment is now used—amounts to about 1,000 tons per day, or more than 40% of total production; and the company is advancing towards its goal of filtering all sulphur mined. Despite the obvious success and all-round efficiency already achieved, the determination remains to improve still further on the company's com-

petitive position. Natural gas is now used for heating its 5,500,000 gallons per day boilers. This is slightly cheaper than oil and less maintenance is required. The oil burners are kept in reserve.

Gulf Sulphur Corporation. While in terms of volume the company's expansion in sales to the home and foreign markets was smaller than in the instance of its competitor, proportionately Gulf Sulphur's advance was even more striking:—

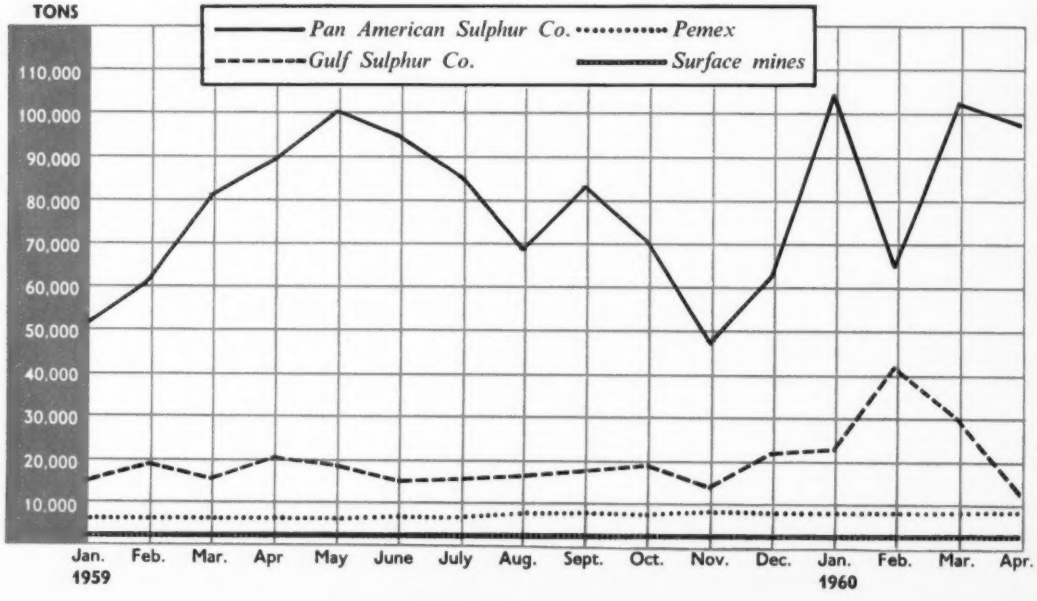
	First Quarter ('000 tons) 1958	First Quarter ('000 tons) 1959	Change	Change %
Production ...	74.0	57.8	−17.3	− 22
Exports	46.7	88.2	+41.6	+ 89
Domestic Sales ...	0.3	4.7	+ 4.4	+1,550
Total Deliveries ...	47.0	93.0	+46.0	+ 98

Stocks fell by some 35,000 tons to a level of about 68,000 tons, both on account of the higher sales and also the lower rate of production, amounting to a daily average of less than 650 tons. On the basis of a past statement by the company's vice-president, Mr. Robert H. Allen, it is thought that an output of between 700 and 750 tons per day is required to make operations more than merely marginal. Run of the mine sulphur contains 0.35% carbon, but filtered brimstone has 0.05% carbon, 0.005% ash, 0.005% moisture, and 99.9% sulphur. Acid treatment is used in filtration.

Texas Gulf Sulphur Company. The Nopalapa dome continued to produce at its normal rate of some 10,000 tons per month until it was closed down:—

	First Quarter ('000 tons) 1958	First Quarter ('000 tons) 1959	Change	Change %
Production ...	30.1	14.5	−15.6	−52

Between February 7th 1957 and February 15th 1960, almost 400,000 tons of sulphur were produced, all of which remains stockpiled at the site and surrounded by the jungle. As far as is known the company has no plans for selling the sulphur, which will presumably be left where it is for some years until such time as the market may recover sufficiently to make it worthwhile to shift it to Coatzacoalcos and there erect the necessary loading installations. When in 1955 by agreement with the Mexican Government the company decided to build a plant to come on stream early in 1957, the price of sulphur was of course very much higher than it is now. Moreover production costs had increased, and in any event the company's Frasch plants in the United States were more economical to operate and were not functioning near to their capacity.



It is not known whether any further use will be made of the Frasch plant, which was built by Brown and Root Incorporated with a hot water rating of 500,000 gallons per day and mounted on a double marine hull. It is the second Frasch plant so far to have been closed down in Mexico. The first — that of the now bankrupt Mexican Gulf Sulphur Company—is now the property of the Patrimonio Nacional, which apparently still pays a Government engineer and a watchman to look after it.

Others. In January 500 tons were produced by the *International Sulphur Company* from their Texistipec dome. Since then the dome has been kept hot but there appears to have been no further output. It is rumoured that the widening and deepening of the company's small waterway to Coatzacoalcos will be completed in June or July of this year. However the time could hardly be less auspicious for the entry of another Frasch producer to the world market. Nevertheless the *Sulphur Exploration Company* are still drilling. At the annual meeting in Houston last December George P. Mitchell was elected President. He told the stockholders that under the terms of the contract with the Mexican Government the exploration period would end in 1960, in which year twenty-nine additional wells would be drilled, bringing the total number of wells sunk on the concession to one hundred and forty-four. It has been stated that the company's proven reserve of recoverable sulphur amounts to some 2,600,000 tons. While it has been suggested that an extraction plant might be built by 1963, this would appear to be manifestly improbable in the absence of the assured captive market which the company is said to require before going ahead.

Recovered Sulphur

Petroleos Mexicanos. The output of recovered sulphur showed a considerable increase:—

	First Quarter ('000 tons) 1958	First Quarter 1959	Change	%
Production ...	14.6	21.6	+7.0	+48
Domestic Sales ...	15.0	21.0	+6.0	+40

The additional production may be accounted for by the coming on stream of the sulphur recovery plants at the Mexico City and Tampico oil refineries with daily capacities of 25 and 30 tons respectively. These bring the company's total sulphur recovery capacity to 195 tons per day, the other 140 tons being the capacity of the older unit at the Poza Rica natural gas cleaning plant. A considerable increase in natural gas sales will follow on the completion of the gas pipelines now being built, and while it is understood that in the first place the extra natural gas will be drawn from Mexico's sweet gas fields, the volume of sour gas treated is ultimately expected to rise considerably. In particular it is planned to export more natural gas to Texas and the proximity of the sour Poza Rica gas field to this market makes Poza Rica the logical source of supply. The output of recovered sulphur by Petroleos Mexicanos is expected to start rising again in 1961. The sulphur is sold at the same prices as those charged in the domestic market by the Frasch producers—280 pesos (U.S. $22.40) per ton for acid manufacture and 350 pesos (U.S. $28.00) per ton for non-acid use.

Sulphur from Native Ores

Negociacion Minera S.A. According to the figures issued by the Instituto Mexicano de Azufre, production increased marginally and sales did likewise:—

	First Quarter ('000 tons) 1959	First Quarter 1960	Change	%
Production	4.3	4.5	+.2	+4
Domestic sales ...	4.3	4.5	+.2	+4

However, little significance attaches to this, for while monthly output now averages 1,000 tons, small unreported fluctuations from month to month occur as well as minor fluctuations in stocks. No ore is used as such for agricultural purposes and all is refined in autoclaves. This is then filtered to remove most of the ash, the proportion of which in the final product is .005%. The carbon content is .002% and the material is 99.9% sulphur. This is sold locally around San Luis Potosi and in the Tampico district for making sulphuric acid and carbon disulphide. The price at which the company sells is 395 pesos (U.S. $31.60) per ton, the difference between this and the prices charged by Petroleos Mexicanos and the Frasch producers being accounted for by transport costs to the area.

1st Quarter's Results
('000 TONS)

	Frasch	Recovered	Native	Total
Production	285.3 (−8%)	21.6 (+48.%)	4.5 (+4%)	311.3 (−6%)
Exports	350.1 (+50%)	—	—	350.2 (+50%)
Domestic Sales	12.3 (+82%)	21.0 (+48%)	4.5 (+4%)	37.8 (+45%)
Total Deliveries	362.5 (+50%)	21.0 (+48%)	4.5 (+4%)	388.0 (+49%)
Addition to Stock	−77.2	+.6	—	−96.6
Stocks at 31.3.60	c. 956.0	not available	not available	c. 956.0

Percentages refer to comparison of first quarters' results 1959 and 1960.

Outlook

Little change is expected in the position of the surface mines, the management of which remains content to supply an isolated and restricted area at a price which would elsewhere be considered high. It will not be long before increasing output by Petroleos Mexicanos exerts a greater influence on the sales of the Frasch producers in the home market. In the far more important export field the prevailing basic prices — U.S. $20.50 per ton f.o.b port for dark sulphur and U.S. $21.50 per ton f.o.b. port for bright material—have been too low to bring satisfactory returns from even the recent sales, high in terms of volume though they have undoubtedly been.

Economic Aspects of Courtauld's Carbon Disulphide Recovery Plant

JUST over a year ago Courtaulds Ltd. completed facilities at their Greenfield Works, near Holywell, North Wales, for the recovery of substantial quantities of carbon disulphide from the viscose rayon staple fibre plant at the same works. The £600,000 plant, code name Landmark, recovers 90% of the CS_2 from the viscose rayon plant's foul air which contains considerable amounts of CS_2 and H_2S at low concentrations (1000 and 350 p.p.m. respectively).* In fact 80 to 85% of the CS_2 used in the viscose process leaves the plant in the foul air as CS_2. Of the two gases hydrogen sulphide as such is of no further use in rayon production. Its removal is expensive, but compulsory in all new rayon plants in the U.K. Carbon disulphide, however is the principal chemical used in production of rayon and a substantial quantity is released as a gas.

Some 10 years ago Courtaulds began investigations into the possibilities of recovering economic amounts of CS_2 for if recovered economically it affords a large saving as well as reducing atmospheric pollution. CS_2 is removed from the foul air in the Landmark plant by adsorption on active carbon. The foul air fluidises five beds of active carbon in the adsorber through which the air and carbon flow counter current to one another. The CS_2 is recovered from the carbon by steaming; the carbon is then dried, cooled and returned to the adsorber.

Most of the H_2S in the foul air is removed in an adsorbtion plant before the air enters the adsorber. The carbon removes much of the remaining H_2S. Since this H_2S poisons the carbon, a continuous regeneration unit is included in the Landmark plant, fed with a side-stream which removes the contaminants and maintains carbon activity.

Cost Estimates as Guide

The crucial factor in plant and process development are financial and the steps taken to bring Courtauld's new process from laboratory-scale to full-scale commercial plant reflect this. D. A. Cuthbert and M. J. Hagger of Courtaulds Ltd. in a paper presented at a recent meeting of the Midlands Branch of the Institution of Chemical Engineers in Birmingham showed how cost estimates guided research efforts and how economics dictated the pro-

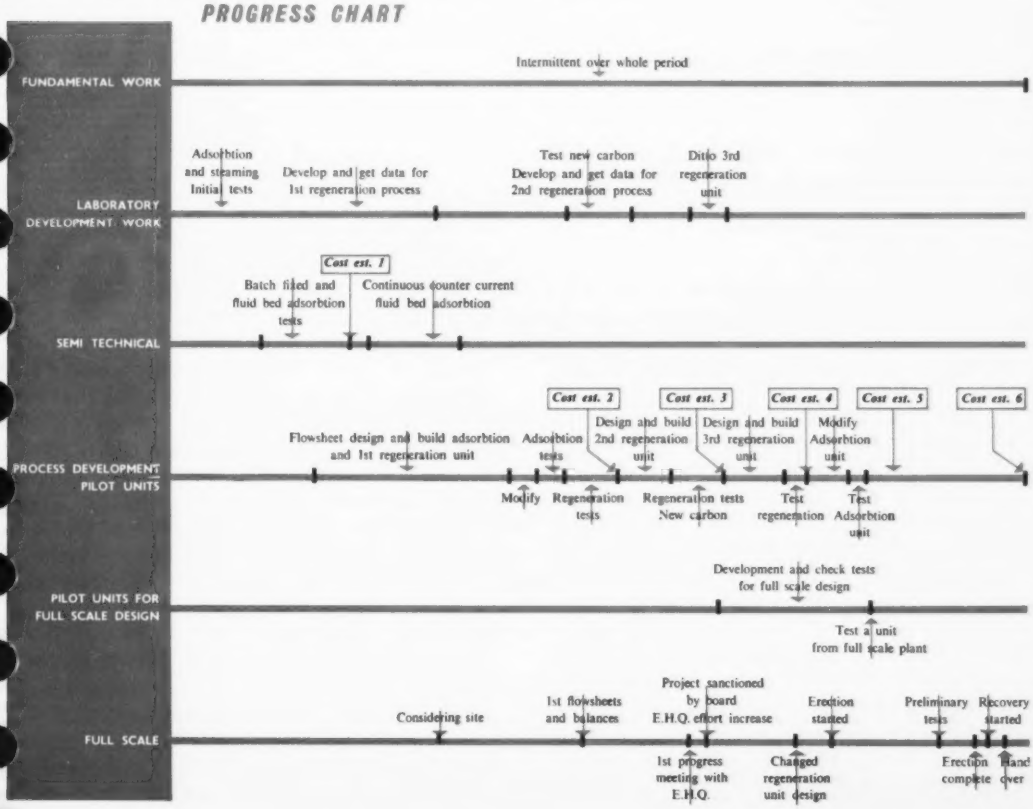
*SULPHUR, July 1959

cedure followed in developing the process. First estimates of the recovery cost after the first batch-wide semi-technical scale tests in 4in. dia. glass column showed that the project might save £200,000 to £300,000 a year and have a return on capital of 70 to 100%. To save time and thereby expenditure, design and laboratory work was kept ahead of the current pilot-plant work. Prototype units were avoided and the full scale plant was designed on the results of tests on very small units representing scale-up factors of 100 and over; this enabled the cost of the development to be kept down and had the added advantage that small units could be assembled and modified quickly so saving time.

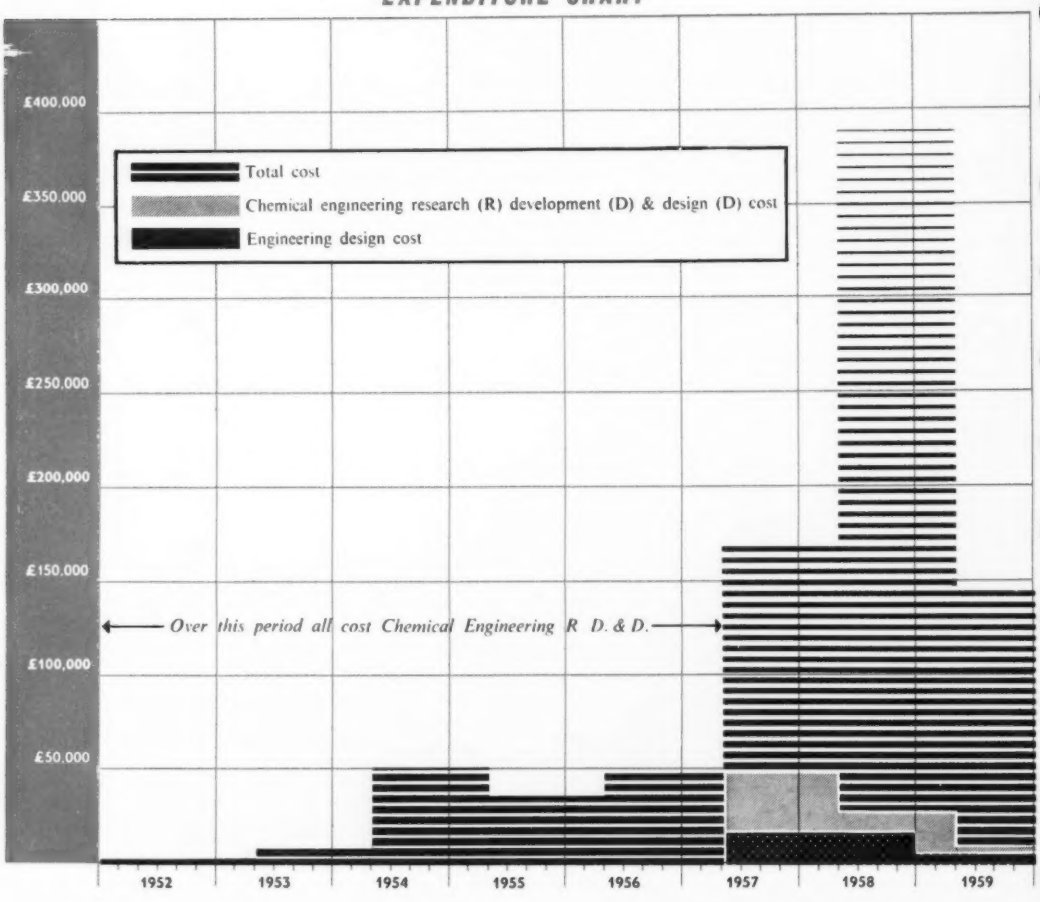
Periodic assessment of the recovery cost was carried out so that whereas the first estimated capital cost in 1953 was based on cost per ton for fixed-bed acetone recovery plant and assumed a recovery rate of 0.81 tons CS_2 an hour, pilot-plant with make-shift batch regeneration unit had to account for high carbon cost due to the regeneration process softening the carbon. In 1956 the assumed capital was put at £350,000 on an assumed recovery rate of 1.1 tons CS_2 an hour. By February 1957 the capital cost had risen to £475,000 with a preliminary estimate based on full-scale plant flow sheets. By October of that year, a reduction in carbon cost was possible using a third regeneration process.

Based on the results of a final pilot-plant run in September 1958, the capital cost was put at £550,000. An estimate was made in October 1959 shortly after commissioning. A recovery rate of 1.1 tons an hour from the design was expected with the recovery cost index at about 105, but since the factory was not putting as much material through the plant as had been expected, recovery rate was 0.92 tons CS_2 an hour, and the final capital cost assumed was £580,000.

PROGRESS CHART


FUNDAMENTAL WORK
Intermittent over whole period
LABORATORY DEVELOPMENT WORK
Adsorbtion and steaming Initial tests
Develop and get data for 1st regeneration process
Test new carbon
Develop and get data for 2nd regeneration process
Ditto 3rd regeneration unit
SEMI TECHNICAL
Cost est. 1
Batch filed and fluid bed adsorbtion tests
Continuous counter current fluid bed adsorbtion
PROCESS DEVELOPMENT PILOT UNITS
Cost est. 2
Cost est. 3
Cost est. 4
Cost est. 5
Cost est. 6
Flowsheet design and build adsorbtion and 1st regeneration unit
Adsorbtion tests
Design and build 2nd regeneration unit
Design and build 3rd regeneration unit
Modify Adsorbtion unit
Modify
Regeneration tests
Regeneration tests New carbon
Test regeneration
Test Adsorbtion unit
PILOT UNITS FOR FULL SCALE DESIGN
Development and check tests for full scale design
Test a unit from full scale plant
FULL SCALE
Considering site
1st flowsheets and balances
Project sanctioned by board E.H.Q. effort increase
Erection started
Preliminary tests
Recovery started
1st progress meeting with E.H.Q.
Changed regeneration unit design
Erection complete
Hand over

EXPENDITURE CHART



In the second cost estimate the carbon cost—due to attrition—was much higher than the first estimate. The next highest cost was services, namely steam. Efforts were therefore concentrated on reducing the carbon and steam consumptions. After testing cheaper and harder carbons a regeneration process was developed that did not weaken the carbon, and following fundamental research work a double-effect stripping/drying process was developed which reduced steam costs. Plant cost increased as equipment costs increased and as a more accurate idea of plant design was gained.

In considering whether to proceed with the project, the rate at which to proceed, and economics as indicated by profitability calculations, other factors had to be taken into account by the Courtaulds' investigators. This applied primarily to the social aspect of reduction of atmospheric pollution even if the process was not very profitable. It was realised, too, that the unit would be expensive since it would be the first and would entail major modifications, in particular to the foul air extraction system which would only become practical when the plant had operated and proved profitable. Future units would obviously be much cheaper.

At present total carbon disulphide consumption in the U.K. by viscose rayon, transparent cellulose film ("Cellophane") and for other uses, is at an annual level of about 60,000 tons. The Landmark plant, it is estimated, could effect a saving of up to 8,000 tons a year.

current events

Canadian Developments in Production of Sulphur and Oil from Tar Sands

ACCORDING to Great Canadian Oil Sands Ltd., New York, production of oil from Alberta's Athabaska tar sands by 1963 will be possible. This will open a major new source of sulphur. The company has filed an application with the Alberta Oil and Gas Conservation Board for approval of a $100 million project to mine, process and market synthetic crude oil and by-products from the McMurray oil sands of the Mildred-Ruth Lakes area, which form the world's greatest single reserve of crude oil, containing an estimated 300,000 million barrels of retrievable oil and representing a reserve 2,100 million tons of sulphur.

Many attempts have been made to find ways of extracting oil on a basis which is feasible technically and commercially. Last October it was announced that preparations were being made to use an atomic explosion under the sands in the hope that the resultant heat would free the oil. Interested in this project were Richfield Oil Inc. of Los Angeles.

Great Canadian's project will produce an estimated 31,500 barrels of crude oil daily. In the company's submission to the Alberta Oil and Gas Conservation Board, it says it has made arrangements for sale of most of the output. Sun Oil Co have contracted for 15,000 barrels a day, and Canadian Oil for 5,000 barrels a day, for processing into various petroleum and petrochemical products. The crude oil could be marketed at the same price as petroleum base crude.

Estimated to require capital of $111 million, the project would involve a strip mining process, by bucket wheel excavators, a water flotation process to separate bitumen from sand, an oil processing plant and transportation by 16-inch pipeline to connect with the Inter Provincial Pipe Line system at Edmonton 175 miles away. Operation would be based on a lease area estimated to contain 900 million barrels of bitumen.

Should Great Canadian get the Board's approval, the company plans to begin construction on the facility later this year, to start production in the autumn of 1962 and to reach full production by 1963.

A hot-water-wash process, which has been demonstrated in a 500-ton/day pilot plant, will extract the bitumen from mined sand. The bitumen is then deareated, dried and fed to a coking operation where naphtha and gas oil are produced. Both streams are desulphurised, and then blended into synthetic crude oil for sale. No plans have been announced by Great Canadian for marketing by-products such as sulphur, fuel gas, fuel oil or coke. Principal contractors are Link-Belt of Toronto and Lubecker Machinenbau of Germany.

Also interested in oil sands are the group comprising Richfield Oil, Cities Service, Imperial Oil, Royalite co-operating with Can-Amera Oil Sands who also expect to receive Board approval.

A major factor in the development of these bitumenous sands is the simultaneous production of sulphur. Sulphur content varies between 4.5 and 5.5% by weight of the dry bitumen and is in chemical combination with it Although some crude oils contain between 2 and 3% sulphur most crudes contain less than 1.75% of sulphur. Distillation of the bitumen reveals that the sulphur is found to be fairly uniformly distributed throughout the whole range of distillates. Modern oil refining, however, enables economic processing of high sulphur crudes. The sulphur content of the bitumen is liberated in the course of the hydrogenation step and this entails removal of H_2S following hydrogenation of the distillate. The amount of sulphur involved in these tar

sands is estimated at 1.5 million tons of sulphur per square mile, and treatment of the bitumen present would lead to the recovery of some 900,000 tons of elemental sulphur. The projected plant — to produce 31,500 barrels of oil a day — would lead to a sulphur production of 78,720 tons a year.

Natural Gas Export Projects

Export of more than 200 million cu. ft./day of natural gas to the U.S. Midwest from Canada is expected to be under way by 1st October and later in the year further quantities may cross the border at Niagara Falls. A recent Canadian Government decision authorised the Niagara Gas Transmission Co., a subsidiary of Consumers' Gas of Toronto, to export 73,500 million cu. ft. of natural gas to Northern New York State over the next 20 years. In addition, Trans Canada Pipe Lines are also permitted to export gas across the border at Niagara up to a maximum of 204 million cu. ft./day on a completely interruptable basis. This is supplementary to the Government's approval of the company's application to export up to 204 million cu. ft./day of gas across the border at Emerson, Manitoba. Construction of the necessary facilities by Trans Canada is to be rushed ahead so that export through Emerson can begin by 1st November.

Meantime, further natural gas pipeline projects are being progressed. Alberta Gas Trunk Line Co. Ltd., Calgary, are to raise $30 million to complete construction of the $72 million Plains Division of their pipeline system. Overall length of the Plains Division line, leading towards Northern Idaho, is 834 miles, with a capacity of 731 million cu. ft./day. It had been hoped that construction of the new $110 million pipeline would start later this year. Because of procedural difficulties and unexpected and very stubborn opposition, plans to start construction of the pipeline this summer have been delayed. Still awaited is the final authorisation by the California Public Utilities Commission and the U.S. Federal Power Commission. Clearance from these two agencies may not now be obtained until late autumn.

Alberta Gas Trunks plan to build a new gas gathering system — to be called Foothills Division — to supplement their Plains Division which supplies gas to Trans Canada Pipelines. Foothills Division, which is to supply the Alberta and Southern Gas Company and the Westcoast Transmission Company, was originally planned to be built during the summer construction seasons of this year and next year, with completion scheduled for November 1961. The loss of the 1960 construction season will not necessarily push the completion of the pipeline construction a year beyond the November 1961 target date, but it may result in a crash construction programme which would increase costs materially.

Plans are moving forward for construction of plants and facilities for processing natural gas of the East Calgary field in which Jefferson Lake Petrochemicals of Canada Ltd. and Mobil Oil of Canada Ltd. have the largest acreage and proven reserve position. Approximately 100 million cu. ft./day of pipeline gas will be provided for delivery to Westcoast Transmission Co. under long-term contract and will produce besides liquid hydrocarbons some 800 tons of sulphur a day. The issuance of export-import permits authorising the same and transportation of natural gas through pipeline from Canada into the U.S. is awaited.

W. C. Holmes desulphurisation and benzole defronting unit at Isle of Grain Works

Canadian gas is welcomed by the U.S. to effectively lengthen the U.S.A.'s oven natural gas sources. For Canada it will mean a boom for Canadian gas and oil, but will create a problem with regard to sulphur. Although Canada consumes about 6% of the world total of sulphur, her production of elemental sulphur total has been about 0.7% of world production and her imports less than 3% of the same figure. However, sulphur to meet requirements is obtained from smelter gas.

UNITED KINGDOM

S.A.I.'s £1m. Reconstruction Plans

Plans to reconstruct their Sandilands, Aberdeen, fertilizer works at a cost of more than £1 million have been announced by Scottish Agricultural Industries Ltd. Taken over by S.A.I. in 1928, modernisation of Sandilands will begin this year with completion scheduled for the summer of 1962. On completion this plant will produce concentrated complete fertilizers (C.C.F.) instead of superphosphate-based products as at present. S.A.I. now produce C.C.F. at their Leith works. It is thought that demand for this range will exceed supply in the next few years unless additional capacity is provided.

The company's acid plant, a flash roaster installed in the early 1950's, is based on flotation pyrites mainly from Sweden.

INDIA

New Superphosphate Factory

Site of the new superphosphate fertilizer factory of Dharamsi Morarji Chemical Co. Ltd., India, is the village of Kumhari on the Nagpur-Raipur railway line about 10 miles from Bhilai. It will be the first one in the State of Madhya Pradesh to manufacture fertilizer although ammonium sulphate has been produced as by-product at the Bhilai steel project for the last four months.

The bulk of the component parts of all the plants will be indigenously fabricated. The installations will include a contact-type sulphur acid plant of 50-tons-a-day capacity; and a Broadfield unit of six to 10-tons-an-hour capacity for superphosphate manufacture. The factory is scheduled to start production by the end of this year. Annual production of the Kumhari fertilizer works will be 18,000 tons sulphuric acid (100% H_2SO_4), 43,200 tons superphosphate and 3,600 tons aluminium sulphate.

This new fertilizer factory should contribute greatly towards increasing food production in Madhya Pradesh. Dharamsi Morarji Chemical Co. hope that means can be found to utilise effectively supplies of nitrogenous fertilizer from Bhilai steel plant in combination with the superphosphate produced at Kumhari. Supplying fertilizers as balanced mixtures in a ready-made form to farmers in the State is expected to be more conducive to raising agricultural production than supplying any single fertilizer, such as ammonium sulphate or superphosphate.

Sulphuric acid plants at present in operation in Madhya Pradesh are the new contact plants using brimstone of 25 tons/day of Gwalior Rayon Silk Manufacturing Co. Ltd. at Nagda. These came on stream in 1955 and 1958 respectively.

Due in operation in May-June was the 37 tons/day contact sulphuric acid plant of Hindustan Steel (Private) Ltd. at Bhilai, while expected to be on stream in the near future is the 50 tons/day contact plant of Pioneer Chemical Industries (India) Ltd. at Najpur.

UNITED STATES

Tidelands Case Decision

Upswing in the exploration for oil, sulphur and other minerals in the Gulf of Mexico may result from the Supreme Court decision at the end of May in the tidelands case. By a vote of five to two the high court ruled that Texas and Florida own the submerged lands extending from their coastlines 10½ miles into the gulf, but that the jurisdiction of Alabama, Louisiana and Mississippi end three miles from their coastlines. Beyond the limits set by the Court, the submerged lands belong to the Federal Government. The Supreme Court's decision means that the Federal Government will pick up about $300 m. from mineral leases issued in the disputed areas since 1950; during this period the interior department continued to issue leases and put the money in escrow pending a final decision from the Court. This decision is of major importance to the Frasch sulphur producers as it is widely held that new dome reserves are very likely to be discovered in offshore locations.

FRANCE

More Acid for TiO_2

One of the Continent's main producers and exporters of titanium oxide, Societe des Fabriques de Produits Chimiques de Thann et de Mulhouse, with their part subsidiary, Les Produits du Titane, plan a substantial increase in production capacity. The expansion programme envisaged for both companies' plants is 32,500 tonnes in 1961 and 50,500 tonnes in 1962. At present capacity is 12,000 tonnes annually at Thann and 15,000 tonnes at Le Havre, site of Titane's plant.

The plant at Thann was set up in 1924 and is integrated with the Thann and Mulhouse's substantial sulphuric acid facilities which are based on brimstone and indigenous pyrites.

In 1955, in order to fulfil the demand for titanium dioxide, Fabriques de Produits Chimiques de Thann et de Mulhouse in co-operation with Pechiney and Saint Gobain formed Les Produits du Titane to produce titanium dioxide at Le Havre. Capital of this company is distributed 30% to Fabriques de Produits Chimiques de Thann et de Mulhouse and 25% to each of the two partners. The plant with an annual capacity of 15,000 tonnes obtains sulphuric acid from the nearby works of Cie St. Gobain which has a daily capacity of 240 tonnes (100% H_2SO_4) based on brimstone and H_2S. The latter is recovered at the adjacent oil refinery.

GREECE

Major Sulphuric Acid/Fertilizer Project

A 376 - tonnes - a - day sulphur burning sulphuric acid plant which will be the country's largest single-unit acid plant, is to be erected at Ptolemais, in the northern part of Greece, for the Greek Ministeries of Industry and Co-ordination. It will be part of the $36 million nitrogenous fertilizer factory to be built near the Bodossakis lignite mines. The contract for the plant has been awarded to Chemical Construction (G.B.) Ltd., who will furnish the design, engineering, equipment and supervision of construction and initial operation of this plant.

In the gasification of the lignite some H_2S will arise which is to be extracted in an Alkazid-type plant to be supplied by Pintsch-Bamag of Berlin. Up to 15% of the SO_2 feed for the sulphuric plant will be supplied from H_2S and the balance from a brimstone burner. The maximum volume of H_2S expected to become available is 12.7 tonnes per day.

The Ptolemais fertilizer plant will be based on gasification of lignite and 350,000 tonnes of nitrogen fertilizers (containing 90,000 tonnes N) will be produced. About one-third of the production at the plant will be in the form of ammonium sulphate. It is also understood that the Greek Government's Agricultural Economic Planning Commission has had under consideration a proposal to build an ammonium phosphate works in North Greece.

BRAZIL

New H_2SO_4 and Triple Superphosphate Plant

Associated with the construction of the 40,000 tonne triple superphosphate plant for Companhia de Superfosfatos e Produtos Quimicos in Capuava, Brazil, will be the French concern, Ets. Kuhlmann. At the same time a 150 tonnes a day sulphuric acid plant and a 40 tonnes a day phosphoric acid plant will be installed.

Sulphuric acid is at present being produced in Brazil by some 27 plants. Production in 1957 was 252,700 tonnes and in 1958, 253,000 tonnes. Sulphur consumption in Brazil is estimated to be in the region of 80,000 to 90,000 tons annually wholly imported from the U.S.A., and lately also from Mexico. The new facility of Capuava will become Brazil's second triple superphosphate plant, now that Fosforita Olinda at Recipe's plant is nearing completion.

OUTLOOK

Berk's Acid Plants

SULPHURIC Acid Manufacture by F. W. Berk (SULPHUR 28, P.34) is based on two Simon-Carves Monsanto *type* contact acid installations. The plants were designed and constructed by Simon-Carves Ltd.

Sulphur Filter Cake Imports

UNDER the heading "Sulphur Filter Cake" (Prices and Trends, SULPHUR 27) it was reported that Nitrogen Fertilizers Ltd. were the sole users in the U.K. The company inform us, however, that they do not use this material.

COMPANY REPORTS

Marked Improvement in Earnings for Jefferson Lake Sulphur Co.

" . . . decline in the price of sulphur . . . is a direct result of an ill-advised price policy pursued, during the past several years, by the companies in the industry which control the big reserves of sulphur and have large tonnage production and inventories sufficient to supply world demands . . . This policy has caused all companies, whose principal business is sulphur, stupendous losses of earnings from sulphur."

" Those who are fortunate to find themselves in control of large reserves and economical production of this valuable natural resource . . . should voluntarily embrace the principle of conservation and proration which the oil industry practices . . . A policy of continuing to attempt to push more tons into a limited consuming market, pushing price down and down, will lead directly to a financial abyss."

Eugene H. Walet
President
Jefferson Lake Sulphur Co.

MARKED improvement in earnings from actual operations for the year 1959 over 1958 are reported by Jefferson Lake Sulphur Company although they experienced continued weakness and decline in the domestic and export price of sulphur—approximately $1.00 a long ton during the year—coupled with increased hourly wage rates and certain fuel and material costs.

Reviewing 1959, the president, Eugene H. Walet, said that the year had been one of effecting economies and increasing efficiency, and of reconsolidation and transition. The company was gratified with the progress made as a result of the policies pursued and felt that the impact of adverse factors, which had affected earning during the past several years, had been absorbed.

Production

Total production of sulphur during 1959 was 405,970 long tons, compared with 471,300 long tons in the previous year. Of the total, 358,252 tons came from the company's plants in the U.S.A. (313,946 from its own plant and 44,306 tons from Texas Gulf Sulphur Co.) and 47,718 tons from the Canadian operations.

By virtue of exceptional economies, and efficient mining techniques, operations have continued successfully at the Clemens Dome, now in its 23rd year of production, 1959 production being 85,355 long tons and at the Starks Dome where production totalled 87,468 long tons. Best of the three Gulf Coast deposits was the Long Point Dome, where production was 171,900 long tons. Under current operating agreements, mining of limited tonnage is reasonably successful. Sulphur recovered from sour gas at the Manderson, Wyoming, plant totalled 13,529 long tons.

At the 69% -owned Jefferson Lake Petrochemicals of Canada Ltd., production from sour gas at the Peace River Plant, Brunswick, was 47,718 long tons of sulphur against 55,896 long tons in 1958. Stocks at 31st December, 1959, totalled 66,717 long tons of the highest quality (99.9% pure) sulphur.

Sales and Shipments

Total sales and shipments of sulphur for 1959 amounted to 358,359 long tons by Jefferson Lake Sulphur Co., compared with 433,000 long tons in 1958 and 40,372 long tons by the Canadian subsidiary. Exports shipments during the year made through the Sulphur Export Corporation exceeded those of the previous year by 37%. Shipments to Texas Gulf Sulphur Co. for its account amounted to 52,789 long tons.

Finance

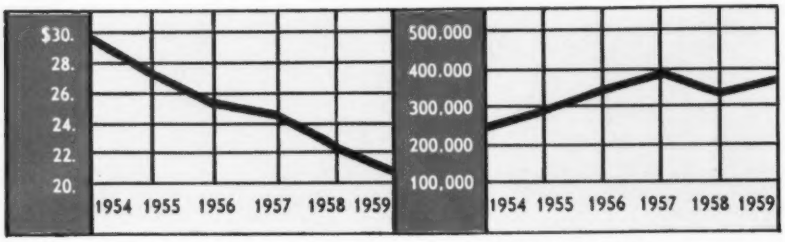
The parent company recorded sales of $10,518,900 ($9,959,694 in 1958) and a net profit of $298,205 ($631,145). The Canadian subsidiary had sales of $684,879, and a net profit of $15,613.

Consolidated net sales and operating revenues of the corporation and its Canadian subsidiary were $11,303,662 in 1959 against $10,028,636 in 1958. Earnings, after various charges, amounted to $307,000 against a loss of $961,000 in 1958, a net improvement of $1,268,000. Charged against operations have been certain special non-recurring items amounting to $1,635,817, resulting in a net loss of $1,328,644.

Consolidated net sales and revenues from each operating division in 1959 were as follows :—

Sulphur	$8,572,366	75.84%
Petrochemicals (Cresylic Acids)	$1,796,631	15.89%
Oil and Gas	$863,697	7.64%
Miscellaneous	$70,968	.63%
Total	$11,303,662	100%

As some 76% of the income of Jefferson Lake Sulphur Co. came from sulphur, the impact of the decline in the price of sulphur has had a direct and accentuated effect on the company's earnings.



AVERAGE F.O.B. MINE PRICES TONNAGE SALES

Special and unusual and non-recurring charges which have been deducted and charged off in 1959 thereby increasing the tax loss carry forward to the benefit of the company were as follows :—

The Manderson, Wyoming, sulphur plant, the Bayou Isle, Louisiana, Rotasorber plant, certain of the Merichem petrochemical plant facilities, and certain filtering and drying and other equipment have been either charged off completely or reduced to "salvage value" ($749,802). This does not affect the Manderson plant, which continues to produce sulphur at a profit.

Operation of the Bayou Isle Rotasorber plant was discontinued, but Atlantic Refining Co. are currently negotiating to operate this plant and National Tank Co. was to place two Rotasorber units into operations. This company also has the option to acquire an exclusive licence to exploit the process and equipment.

The Frasch Process Division has continued certain analysis and research at its laboratories, principally on operating problems and sulphur and water purity.

Sulphur wet bottoms and certain sub-standard grade tonnages of sulphur which had become acidised or contaminated, were reduced to a net realisable value, and are saleable at the reduced prices as "bin bottom" or "sub-standard grade" sulphur.

Price Policy

"Decline in the price of sulphur," remarks the president, "is the direct result of an ill-advised price policy pursued during the past several years by the companies in the industry which control the big reserves of sulphur and have large tonnage production and inventories sufficient to supply world demands. Therefore the small producer is compelled to meet the progressively lower resultant price." Jefferson Lake and their Canadian subsidiary have sold and shipped some 400,000 long tons of sulphur last year which would have returned at the 31st December, 1958, average of the domestic and export prices of sulphur F.O.B. mines, an additional net profit of $2,640,000.

New Project

Transcontinental Gas Pipe Line Corporation and Jefferson Lake have recently reorganised Trans-Jeff Chemical Corporation, Delaware, owned 50% each, for the purpose of producing chemicals to be derived from natural gas and its by-products. The first project of this new company will be the construction of a plant to produce sulphur from concentrated hydrogen sulphide to be furnished by Transcontinental's gas-treating plant at Tilden, Texas.

The contract for the construction of the plant which will cost approximately $255,000 and will produce some 25 tons of the highest grade sulphur a day, has been awarded. Completion is scheduled for September this year. Production of other chemicals is also being studied.

Outlook

Although 1960 posed many problems for the company, Mr. Walet said that it entered the new decade confident that with good liquid cash position, the largest proven reserves—in the company's history, of diversified natural resources, a well-established petrochemical division and an organisation of experienced personnel, it could achieve growth and substantial earnings in the near future. He recommended that those fortunate enough to find themselves in control of large reserves of sulphur should voluntarily embrace the principle of conservation and proration which the oil industry practices under direct Governmental regulations and restrictions. A policy of continuing to attempt to push more tons into a limited consuming market, pushing price down and down would lead directly to a financial abyss.

Gulf Sulphur Corporation Finances

In the review of Gulf Sulphur Corporation's results for 1959 net income before depreciation, depletion and amortization totalled $416,744 and $172,918 for 1958. The net loss for 1959, after applying $584,882 for depreciation, depletion and amortization, totalled $168,138 as against a loss of $530,218 for 1958. There was, therefore, an improvement of $362,080 in 1959 as against 1958 and not an increased loss as suggested under the section, Finance, in SULPHUR No. 28 (P.41).

Sulphur Shipments from Texas Gulf Exceeded Production in 1959

"Increased demand for elemental sulphur is a favourable sign to Frasch producers. However, the low price of sulphur as currently quoted and excess supplies in the market have adversely affected net receipts per ton and industry earnings . . . Barring a downturn in the general industrial economy, we expect that 1960 will see another substantial gain in world sulphur consumption."

Fred M. Nelson
Chairman

Claude O. Stephens
President
Texas Gulf Sulphur Co.

REVIEWING the activities of Texas Gulf Sulphur Corporation in 1959, president Mr. Claude O. Stephens and chairman Mr. Fred M. Nelson, in their annual report note that the company completed its first half-century of corporate existence. The past year also marked the 40th anniversary of Texas Gulf Sulphur's first production of sulphur, and the 30th anniversary of production at Boling Dome, the world's most productive sulphur deposit.

Production

Some 2,300,000 long tons of sulphur were produced by Texas Gulf during 1959 and of this about 90% was produced at the four Frasch mines in Texas—Boling, Spindletop, Moss Bluff and Fannett. The company has also continued to share in the Frasch sulphur produced at Long Point, Texas. Approximately 60,000 tons of sulphur was recovered from sour natural gas at Texas Gulf's Wyoming plant near Worland. A similar plant has been constructed at Okotoks, Alberta, jointly with other companies. Production began in June last year and exceeded 50,000 tons by the end of the year. In recent months, the plant has been operating at the rate of 130,000 long tons of sulphur annually, recovering some 4,500 million cu. ft. of sweet gas and some condensates in the process. The company participates to the extent of 42.5% in revenues from sales, not only of the sulphur, but also of the gas and condensates.

The company's Mexican subsidiary at Nopalapa Dome produced about 100,000 tons of sulphur, all of which was placed in inventory. Under this subsidiary's contract with the Mexican Government, sulphur production had to begin early in 1957. At the time the plant was projected (1955), sulphur price and demand were strong. Operating costs, to-day, have increased, however, and the price of sulphur is lower by several dollars per ton. Texas Gulf's domestic plants are producing at lower cost than the Mexican subsidiary, and are themselves operating well below capacity. As a matter of economy, therefore, operation of the Mexican plant was suspended in February of this year. The Frasch plant in Mexico is only of modest capacity, accounting for only about 4% of the company's annual output. The suspension and later decisions regarding the subsidiary will have no adverse effect on the company's financial position.

Sales

Gross revenue from sales of Texas Gulf increased by 11.5% in 1959 to $63,596,936 from $57,057,274 in 1958. Sales of oil and gas accounted for $1,749,817 as against $1,771,180 in the preceding year. Sulphur tonnage sold in 1959 was 17% greater than in 1958, an increase exceeding the average for the domestic Frasch industry. Both export tonnage, which accounted for 20% of the total, and domestic shipments, including Canada and Cuba, shared in the increase. Reduced receipts per ton, however, did not allow the growth in dollar sales to keep pace with the gain in tonnage sales.

Finances

Net income for 1959 amounted to $13,338,360 or $1.33 a share, as compared with $13,382,967 or $1.34 per share the previous year. Earnings before taxes were $17,438,300 as against $16,882,967 in 1958. Federal tax in 1959 was $4,100,000, an increase of £600,000 over 1958. Unit costs in sulphur operations were somewhat higher, but these were largely offset by substantially lower costs in oil and gas operations, a decline in exploration costs and a reduction of approximately $450,000 in selling, general and administrative expenses. Dividends amounting to $10,020,000 or $1.00 a share, have been paid, which is the same as in 1958.

The ratio of current assets to current liabilities at the end of 1959 was 10.6 to 1, compared with 11.9 to 1 at the close of 1958. Working capital at $74,312,621 compares with $70,501,095 in 1958. Of the year-end total $32,164,612 was in sulphur stock.

Capital Expenditures

Texas Gulf and their subsidiaries spent a total of $5,300,000 in 1959 for property, plant and equipment, compared with $5,000,000 in the previous year. The principal projects were the completion of the gas processing plant at Okotoks, Alberta, and the construction of sulphur loading docks and storage

facilities at Beaumont, Texas. At the end of February this year, capital expenditures of $5,000,000 had been budgeted for 1960 to be used largely for the construction of a sulphur purification plant at Beaumont, and facilities for handling molten sulphur at key distribution centres in areas other than Texas.

Research and Development

Activities have been devoted to three major areas; improvement in existing processes and products; efforts to commercialise new sulphur or sulphur-value sources; and, research of fundamental nature. The programme concerned with the commercialisation of new sulphur-value sources involves studies to improve methods of extracting associated metal value.

A major pilot plant has been operated since 1957 to select and develop an economic process for upgrading dark sulphur as to its colour and carbon content. Last year, Texas Gulf report, a successful process was developed, and the company has decided to construct a plant to be located adjacent to the new marine shipping terminal at Beaumont. It is expected to be in operation by mid-year 1960.

The Sudbury, Ontario, pilot-plant to determine the economic feasibility of recovering elemental sulphur from the sulphur dioxide in smelter gas, continues to be operated. Much valuable engineering information has been secured, but further operations are still necessary.

In the field of sulphur recovery from sour natural gas, a research programme is being carried out both to determine the behaviour pattern of gas reservoirs, and to improve the treating processes by which the sulphur is recovered from the gas produced.

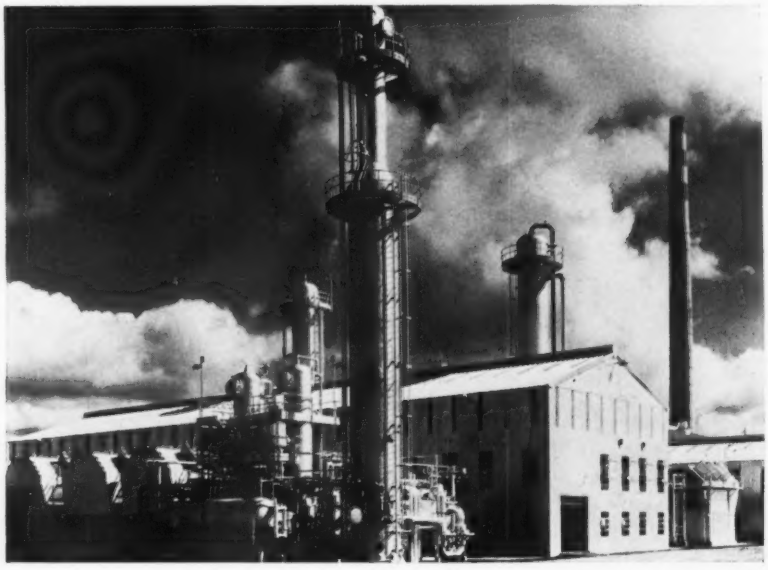
The Sulphur Market

The year 1959 saw a considerable improvement in the world sulphur market. At a record level of 16,000,000 long tons, total free world sulphur consumption shows a gain of 5% over 1958, and compares with the 1956 consumption level of somewhat less than 15,800,000 tons. The rise last year is ascribed solely to a greater use of elemental sulphur which increased 12% to approximately 8,300,000 tons, while consumption of non-elemental sulphur declined slightly to 7,700,000 tons. Most of the elemental sulphur consumption was extracted by the Frasch method, which supplied 6,200,000 tons or about 485,000 more than in 1958. Notable gains were made by recovered sulphur, however, rising by about 400,000 tons to 1,500,000 tons with most of the increase coming from the Lacq plant in France.

U.S. production of Frasch sulphur was slightly below the 4,643,000 tons produced in 1958, whereas sales rose 12% to 5,186,000 tons, with the result that U.S. Frasch inventories were reduced by 600,000 tons in 1959 to 3,810,000 tons.

Mexican Frasch sulphur shipments to the U.S. rose 6,000 tons in 1959 to 614,000 tons but declined to other countries. Total consumption of Mexican sulphur was about 2% below the 1958 level. Mexican Frasch stockpiles increased 20% during 1959 to approximately 1,000,000 tons.

The increased demand for elemental sulphur is seen as a favourable sign to Frasch producers. The low price of sulphur as currently quoted and excess supplies in the market, however, have adversely affected net receipts per ton and industry earnings. On 1 March the post price of sulphur was only 47%



Sulphur recovery plant at Okotoks in which Texas Gulf have a 42.5% interest

above the level that prevailed during the depression of the "30's," while the average U.S. wages were 257% greater and the average wholesale price of metals and metal products was 147%. Another factor adversely affecting profits of domestic producers is the U.S. Federal law which prohibits use of foreign-flag vessels for shipments from one domestic port to another.

Future Outlook

Barring a downturn in the general industrial economy, Texas Gulf expect that 1960 will see another substantial gain in world sulphur consumption. A large portion of this increase will likely be supplied from expanded production at Lacq, France, and the remainder from Frasch mines and Canadian and U.S. sulphur recovery operations.

For the near term, Texas Gulf expect that sulphur will continue in excess supply and producers will remain in vigorous competition for markets. While the long-term growth in consumption of sulphur will tend to balance demand and supply, new productive capacity now under-way in the industry will defer, at least for a while, this adjustment.

Spanish Market for Pyrites Increasing Report Tharsis Sulphur

"I find myself in agreement with those who believe in the progressive expansion of the demand for sulphur including pyrites, based on the increase of world population and the universal standards of living."

W. P. Rutherford
Chairman
Tharsis Sulphur & Copper Co. Ltd.

DISCUSSING the market for pyrites in his annual report for the Tharsis Sulphur & Copper Company Ltd., chairman Mr. W. P. Rutherford reported that the Spanish market for pyrites was now one of the largest in Europe and was increasing. Residues from pyrites had recently been declared as of "national importance," and Mr. Rutherford states that this legislation will encourage development of treatment plants in Spain already evident.

It had been expected that, following the economic re-organisation established in Spain in July of last year, pyrites would be released from price control and a commercial price would be established between sellers and buyers. While many articles had been liberalised, pyrites had so far remained controlled. It was hoped, however, that pyrites would be decontrolled and that the price would be regulated by the normal commercial process.

The moderate increase in the demand for pyrites noted in the last financial year had continued. This was very welcome to the company, but it had to be realised, Mr. Rutherford said, that in their market of North Europe and Spain, a rapid increase of sales commensurate with the company's potential production capacity as now established could not be expected.

Production

In 1959 637,783 tons of pyrites had been delivered compared with 568,044 tons in 1958—an increase of 69,739 tons or approximately 12%. The completed plant at North Lode was tried out successfully during the year under review. Cupreous pyrites production from Centre Lode was retarded, however, owing to an exceptionally rainy Spring, but production will be resumed during this second half year. Removal of the overburden from the Centre and North open-casts was also hampered by rain in the Autumn. At Calanas, where production is underground, normal working has continued throughout the year.

Calcined Residues Sale

An additional source of revenue has been developed by the sale of calcined residues, which were accumulated during the period of heap roasting last century, when the sulphur was burnt off in the open and lost, and the copper was leached out by irrigation of the residues and recovered by cementation. These residues are high in iron and low in phosphorus and after sintering form a high-class hematite ore for blast furnaces. Demand for this material is good and Tharsis Sulphur expect to ship increasing quantities.

Pyrites versus Sulphur

Competition between sulphur and pyrites continues, Mr. Rutherford notes in his report. Reviewing the position, he states that the advent of a natural gas industry at Lacq in the South of France is the root cause of the oversupply of sulphur in Europe. "In following its programme of gas production, increasing quantities of sulphur are produced to invade markets which were already supplied by U.S.A. and Mexican producers with elemental sulphur. With each producer endeavouring to retain its established position and Lacq determined to place its increasing production of by-product sulphur, the result was inevitable and pyrites as a sulphur ore could not escape from the repercussions." It was fortunate, said Mr. Rutherford, that pyrites after yielding its sulphur contents left 70% of its weight as residues composed of a high-grade hematite iron ore after a treatment which also recovers the copper and other metal contents. He points out that when buyers of Tharsis Sulphur's pyrites deduct the rebate they receive for the residues from the price they pay for pyrites, they are getting the sulphur at a low price. It took time for these facts to be generally realised and accepted but he believed that progress was being made.

STATISTICAL APPENDIX

CANADA

SULPHUR IMPORTS 1958 & 1959

(Short tons)

	1958	1959
United States	374,201	327,613
Mexico	133	4,814
United Kingdom	—	1
Total	**375,331**	**332,429**

SULPHUR EXPORTS 1958 & 1959

(Short tons)

	1958	1959
India	268	—
United States	2,289	26,525
Alaska	5,040	—
Total	**7,607**	**26,525**

PYRITES EXPORTS 1958 & 1959**

	1958	1959
United Kingdom	359,510	217,064
Netherlands	316,036	—
United States	1,203,705	801,544
Total	**1,879,251**	**1,018,608**

**Dollar Value Only

AUSTRALIA

SULPHUR IMPORTS 1957/8-1958/9

(Long Tons)

	1957/8	1958/9
United Kingdom	173	239
New Zealand	7	8
China (Mainland)	—	8,649
West Germany	—	42
Japan	—	3,800
Mexico	57,040	54,768
United States	150,685	106,525
Others	85	22
Total	**208,028**	**174,053**

CYPRUS

PYRITES EXPORTS 1958-59

(Long Tons)

CUPREOUS PYRITES	1958	1959
Belgium	15,570	24,045
West Germany	41,948	45,664
Italy	61,083	54,130
Netherlands	110,220	183,187
Total	**228,821**	**307,026**
IRON PYRITES		
United Kingdom	146,989	105,819
Belgium	37,287	52,147
France	184,027	165,849
West Germany	247,231	136,968
Italy	69,628	105,819
Netherlands	134,673	152,107
New Zealand	—	3,000
Total	**819,835**	**659,370**

SPAIN

EXPORTS OF PYRITES

(Metric Tons)

	1958	1959
West Germany	483,250	465,289
Belgium-Lux.	87,502	113,346
Denmark	80,565	78,001
France	204,584	161,399
Poland	5,623	4,325
Algeria	10,473	1,152
Austria	18,542	21,562
United Kingdom	53,080	44,590
Netherlands	12,695	22,911
Eire	23,665	27,364
Switzerland	3,795	3,006
Hungary	—	4,722
Italy	27,596	6,468
Czechoslovakia	—	11,528
Egypt	56,808	18,445
Tunisia	—	1,790
Total	**1,071,179**	**985,897**

PORTUGAL

CRUDE PYRITES EXPORTS

(Metric Tons)

	1958	1959
Morocco	1,500	1,500
Tunisia	6,150	7,225
Eire	1,880	3,608
United Kingdom	3,601	—
West Germany	64,159	60,701
Belgium-Lux.	111,551	134,693
France	50,275	62,777
Netherlands	116,228	84,889
Algeria	2,050	1,170
Total	**357,394**	**356,563**

YUGOSLAVIA

PYRITES EXPORTS

PYRITES CONCENTRATES	1958	Jan.-Sept. 1959
Austria	7,065	6,492
Italy	41,612	22,590
West Germany	64,638	55,776
East Germany	—	2,841
Poland	50,938	56,021
Czechoslovakia	48,899	10,001
Egypt	36,207	16,000
Total	**279,321**	**168,922**

GREECE

EXPORTS OF PYRITES

	1958	1959
Austria	11,320	6,750
West Germany	9,670	—
Italy	14,820	—
Netherlands	14,130	29,616
Poland	5,000	—
Czechoslavkia	25,417	—
Total	**80,357**	**36,366**

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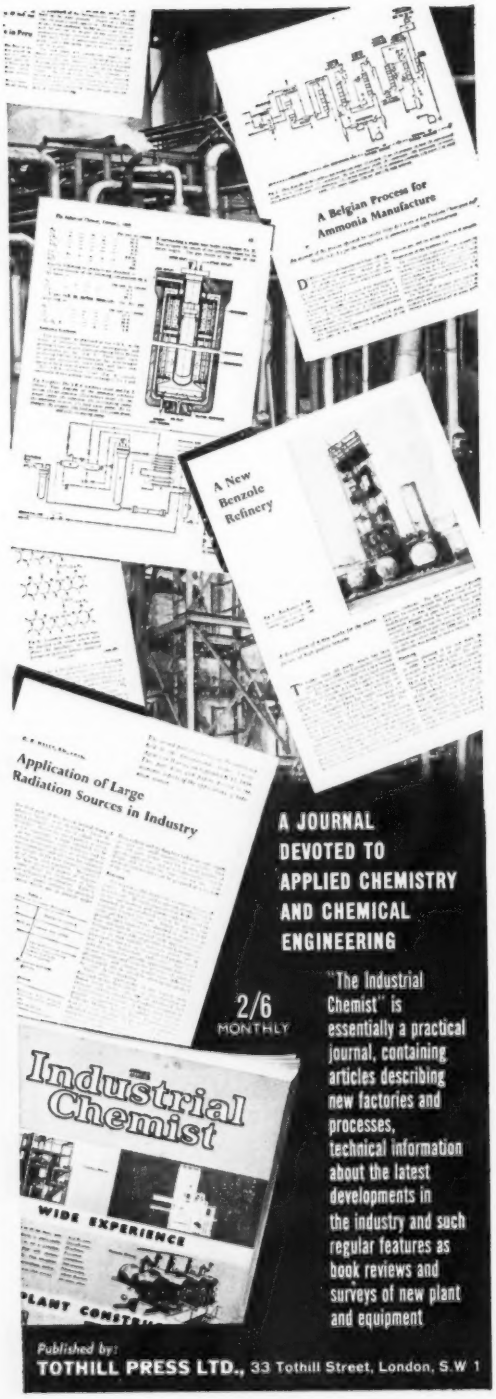
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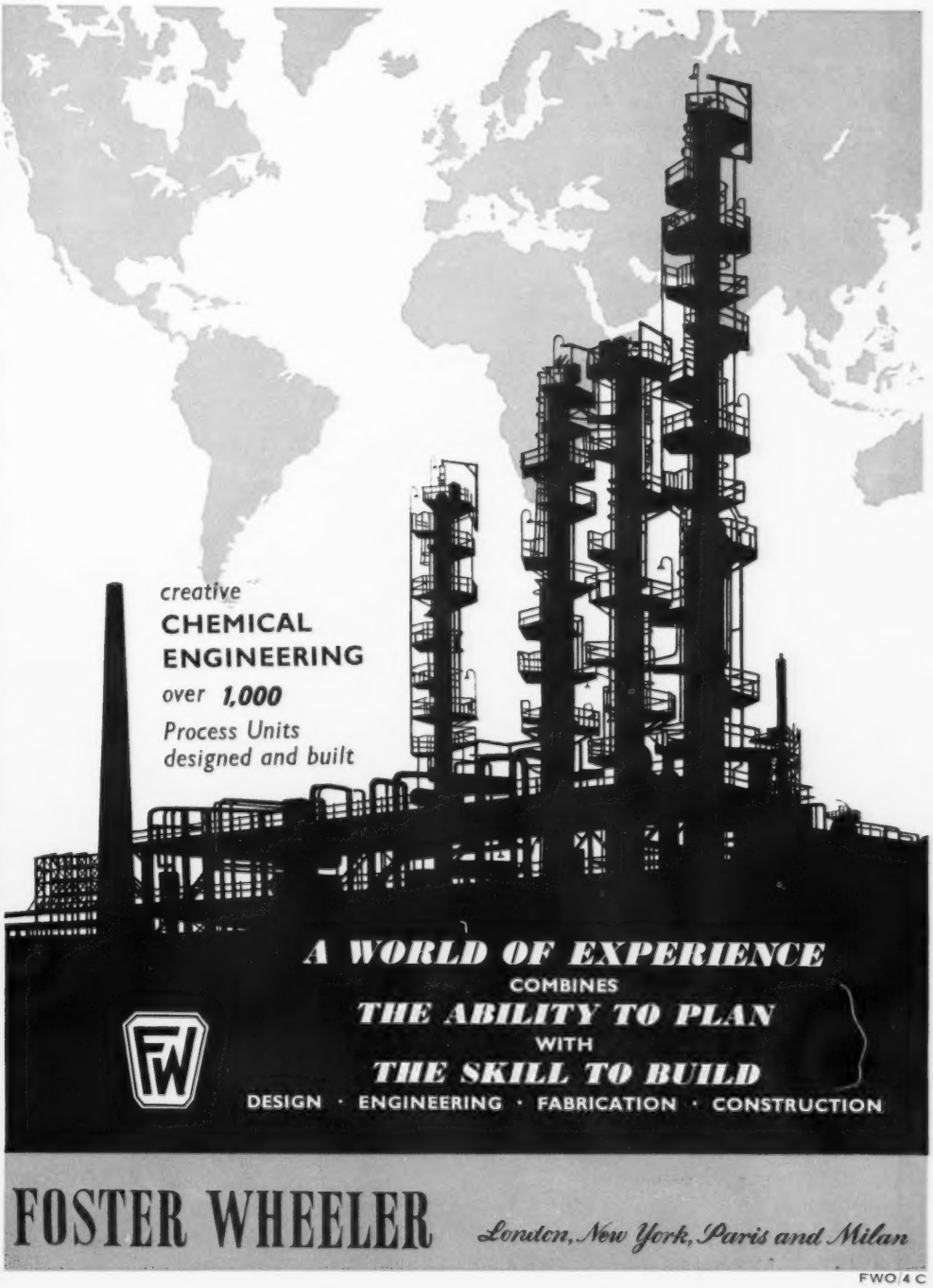
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